1832.

Thos. E. P. Lefroy Esqr.
from S. Hibbert-Ware

# HISTORY

OF THE

# EXTINCT VOLCANOS

OF

# THE BASIN OF NEUWIED,

ON THE

# LOWER RHINE.

Ware

BY SAMUEL HIBBERT, M. D. & F. R. S. ED.

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WITH MAPS, VIEWS, AND OTHER ILLUSTRATIONS.

*Lake of Laach.*

W. AND D. LAING, EDINBURGH:
AND
TREUTTEL AND WURTZ AND RICHTER, LONDON.

1832.

Printed by John Stark, Edinburgh.

LETTER ADDRESSED TO

# M. VON LEONHARD,

PRIVY COUNSELLOR, AND PROFESSOR IN THE UNIVERSITY OF HEIDELBERG.

DEAR SIR,

IN the liberty which, for more reasons than one, I have been induced to take in addressing to you this Memoir, allow me, in the first place, the opportunity to tender my individual deference and respect for talents and exertions like yours, which have so eminently contributed to the advancement of the sciences of mineralogy and geology.

In venturing to explore ground which has been visited by most of your best geologists, I experience a sensation not much unlike that which our sportsmen of England feel when they are trespassing upon a strange manor;—that I have exposed myself to the risk of being warned off. Whether my presumption may admit of a reasonable excuse, it is for you to decide.

The Basin of Neuwied I found to possess geological attractions of no common kind; but it was not before I made a second visit to this spot, that I could possibly persuade myself that I had obtained any tolerable clue whatever towards a rationale of the volcanic phenomena which it exhibited.

It may, notwithstanding, be asked by those who merely know that this district has been frequently visited by naturalists, and that much has been written regarding it,—Under what difficulties, in endeavouring to comprehend its phenomena, I could possibly labour?

In replying to this question I can do little more than make an appeal to some scientific individual, like yourself, who may be

familiar with all that has been written upon this district, and who will be the best enabled, after he has honoured this memoir with his perusal, to say to what extent the volcanos of this district had actually been explored.

That I may not, however, arrogate to myself the acquirement of any new information whatever to which others might reasonably lay claim, I have in every instance to my knowledge avowed the obligations which I have been occasionally under to many eminent geologists who have preceded me in my task, and who, I am sure, if they had deemed this district of the importance in which it has been regarded by myself, and had allowed it to claim a greater proportion of their time and labour, would have rendered to its interesting geology much more ample justice than I could have done.

But,—while the general mass of information contained in this memoir is the result of researches for which I am indebted to no previous author who might have previously treated of the geology of the Basin of Neuwied, allow me to add, that my chief object in writing this memoir has been less to connect my name with any new observations, than to attempt a species of history, of which I have not hitherto seen any unmixed example.

This object cannot be explained without a reference to the general plan of the work, which you will find developed in the Preface, but still more in the copious Table of Contents which I have given.

In submitting to your notice, therefore, "A History of the Extinct Volcanos of the Basin of Neuwied, on the Lower Rhine," accept my best wishes that your valuable labours may be long preserved to the advantage of the University upon which your name reflects so much renown.

I have the honour to remain,

Dear Sir,

Your very faithful and obliged Servant,

S. Hibbert.

Manor Place, Edinburgh,

*April 21st, 1832.*

# PREFACE.

In a long excursion which I made two or three years ago to the Continent, chiefly to examine the volcanic districts of France and Italy, no tract which I investigated appeared to me more replete with interest than that of the Basin of Neuwied, situated upon the Lower Rhine.

Actuated by this impression, I have been induced to draw up the following memoir, though upon a plan, which, in many respects, differs from that of most geological disquisitions.

It has always struck me that geological memoirs would be rendered of far more easy comprehension, if authors, instead of presenting a number of desultory sections of strata, would endeavour to render them subservient to a regular history of the corresponding succession of changes which the surface of the country in which they occur has undergone. This attempt has often been partially made, and with success, but I have not yet seen the geology of a whole district reduced to an undeviating system of this kind. In the present instance, it was for want of such a regular historical view, that in my first attempt to investigate the volcanic eruptions of the Basin of Neuwied, in their complicated relation to tertiary or later deposits, I felt myself embarrassed at every step I took, and, for the solution of my difficulties, was obliged to trust to my own exertions.

Such were the inducements which caused me to attempt a geological memoir upon a plan chalked out by myself. I have sought to connect all the varied volcanic phenomena which the basin of Neuwied presents in a sort of history, in which an attempt has been made to exhibit in succession each physical change which has been going on during the contemporaneous or successive activity of a series of volcanos, remarkable for their number, as well for their being crowded together in a very limited space.

These general observations having been premised, I shall now state, that the amount of information which has been hitherto

communicated regarding the Basin of Neuwied, besides being comparatively sparing, has the disadvantage of being most inconveniently dispersed through numerous works upon the Rheinland in general. A list of these, though rather an imperfect one, may be found at the close of Dr Daubeny's treatise upon volcanos.

Several of these volumes I have occasionally consulted, the titles of which will be found interspersed through the memoir, with the exception of the very miscellaneous treatises upon the Rheinland, published at various times by M. Steininger of Treves, to which I have only generally referred. Their titles I shall therefore now give:—Geognostiche Studien am Mittelrheine, Mainz, 1819;—Die Erloschenen Vulkane in der Eifel, &c. 1820;—Neue Beitrage zur Geschichte der Rheinischen Vulkane, 1821; —Gebirgskarte der Lander zwischen dem Rheine und der Maas, 1822;—Bemerkungen uber die Eifel und die Auvergne, 1824.

But perhaps the greatest inconvenience which the visitor of this country has experienced has arisen from the want of correct geological charts. One which I procured was scarcely entitled to the name of a map, while a second, besides being upon far too small a scale, and deficient in many important particulars, not only in the general directions of the mountains, but in the limits and varieties assigned to the different volcanic rocks and tufaceous deposits, was perfectly inadequate to the conveyance of much information. Under these difficulties, no resource was left me except to attempt a survey of the country myself. This cost me, with no other instrument than a pocket compass, exceeding labour, while the trouble taken by the companion of my journey to construct from these observations the geological map which appears in the frontispiece, was a task still more formidable, which ladies in general do not, I believe, often impose upon themselves. To Mrs Hibbert I likewise owe the whole of the geological sketches which are interspersed throughout the volume.

It was my object to have added to this memoir an account of the eruptions of the Eifel, and of other volcanic districts, for which I have abundant materials. But private engagements, and the state of my health, have prevented me from fulfilling this intention. If I should yet have leisure for the task, and courage

enough to encounter the risk of another expensive publication like this, it is possible I may resume my pen. But in a novel-reading and popular-publication country like our own, scientific objects must be under the restraint of worldly prudence.

After this explanation, I shall address myself to the geological student, who may be inclined to make the Basin of Neuwied an early object of his investigations.

In commencing an examination of the volcanic phenomena of the district, I would recommend him, if he would make himself acquainted with the various circumstances under which they were induced, to previously study in their details the tertiary strata of the district. But, as these deposits are imperfectly developed in the Basin of Neuwied, it would be for the advantage of the student to visit the Brown Coal Pits in the vicinity of Cologne and Bonn,—a brief explanation of the character of which has been introduced in the present memoir.

My other recommendation is a very general one. It is not possible, without considerable inconvenience, to examine the volcanos of the basin of Neuwied in the exact order in which I have described them;—but I would certainly advise the student to adhere as far as it is possible to this order, which is compendiously set forth in the table of contents. Nothing, for instance, will be found to more perplex the mind of the aspirant, than by devoting his earliest attention to the volcanic products of the Laacher-see, the origin and relations of which cannot be well comprehended, until the trachytic eruptions of Rieden and its vicinity have afforded him a preliminary and profitable instruction.

I have lastly to state, that while in this work I have endeavoured to render the description of the eruptions of the Basin of Neuwied subservient to an explanation of the leading phenomena of volcanos in general, I have been further mindful of the convenience of the geological traveller, by preparing for his use a copious table of contents, as well as an index of localities.

S. H.

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# OBSERVATIONS,

SERVING AS AN

# INTRODUCTION

TO THE

# HISTORY OF THE EXTINCT VOLCANOS

OF THE

# BASIN OF NEUWIED.

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In entering upon the study of rocks of igneous origin, the preliminary question which suggests itself to the mind of the student is the general theory which may be safely entertained regarding the ultimate cause of volcanos.

This question is not wholly confined to the novice. There are few geological writers who have not conceived that they were particularly invited to make an attempt, however feeble, to refer volcanos to some general theory connecting itself with the internal constitution of our planet. That the labour has not been fruitless, every one must allow who is familiar with the speculations which are interspersed in the writings of such men as Von Buch and Humboldt. Among other geologists who might be cited, I might mention a few in our own country, namely, Sir Humphry Davy, Dr MacCulloch, Dr Daubeny, Mr Scrope, and Professor Lyell.

But, besides the assistance deduced from practical observers, which has been lent to the solution of volcanic phenomena, physical astronomy, in its laborious analysis, has imparted to it a valuable contribution. From the researches of La Place upon the temperature of the globe, but more particularly from the later ones of Fourier and Cordier, a rational hypothesis may be collected of the periodical convulsions to which the crust of the globe has been subject since its first consolidation. Of this aid, an eminent geologist, M. Elie de Beaumont, has recently availed himself, founding upon it his new views of the elevation of mountain ranges, which, though objectionable in their detail, at least point out to us a mode of interrogating nature in the most mysterious, yet the most sublime of all her operations.

To these modern analytical theories the phenomena of volcanos are indebted for their happiest solution; which result has recently been so well displayed in familiar and intelligible language by an anonymous writer in the Foreign Quarterly Review, that I cannot withhold subjoining a very slight notice of as many of the principles thus inculcated, as will, I conceive, be necessary for the previous knowledge of the geological student; recommending to him at the same time an attentive perusal of the original article, as well as the authorities upon which the useful comments of the critic have been founded. (See the *Théorie Analytique de la chaleur, par M. Fourier.—Essai sur le Température de l'Intérieur de la Terre, par M. Cordier*, from the *Mémoires de l'Academie Royale des Sciences.*—The Foreign Quarterly Review, No. 16, for October 1831, page 303, &c. &c.)

The spheroidal form of the earth, the disposition of its materials in the form of elliptical and concentric layers, together with the gradual increase of the density of these layers keeping pace with their depth, are the chief evidences of the original liquefaction of the terrestrial mass. But as its mean density is only five times greater than that of water, which is inconsistent with the notion of the uncontrolled compressibility of its materials, it is supposed that at considerable depths an enormous pressure is either counteracted by the antagonist force of heat, or by the presence of some substance possessing sufficient elasticity or internal repulsion among its molecules to resist the effects of compression.

The heat accumulated within the interior of the globe is to be sought for after we have passed the comparatively thin limits of annual variation, to which a superficial portion of the earth's crust, scarcely amounting to more than 65 yards in depth, is subject from the annual action of the sun's rays.

That the internal heat thus accumulated should have caused an augmentation of temperature in the superficial crust above what is due to the heating effects of the sun, is an anticipation which is countenanced by the labours of the analyst, as well as the experimental observer. But this excess, which must formerly have been much greater than at the present day, cannot now be rated, (owing to the reduced conducting powers of the envelope,) at more than the thirtieth part of a centesimal degree.

The dissipation of this internal heat is at present so slow as to be almost imperceptible; yet, in the course of an almost immeasurable lapse of time, several important changes must have ensued.

In the *first* place, a contraction must have taken place in the dimensions of the interior fluid mass;

*Secondly*, an acceleration, proportional to this contraction, must have occurred in its rotatory motion; while,

*Thirdly*, a gradual consolidation must have ensued of the exterior and thin crust of the globe; the ultimate thickness of which, although the process of consolidation has been continued through countless ages, does not perhaps exceed in vertical descent sixty miles.

We are also, through the same means of investigation, instructed, that, in a given geological epoch, which, when compared with the historical monuments of the human race, must be regarded as almost immeasurable, the secular refrigeration of the exterior crust of the globe, the materials of which possess inferior conducting powers, would not only proceed at a slower rate than that of its interior fluid mass, but that other effects would result from this inequality of cooling which it is of importance to appreciate.

After the initial process of consolidation had taken place of the crust of the globe, which in a primitive epoch must have commenced at the surface and proceeded towards the interior, the interior fluid mass would be surrounded by its thin consolidated crust as by an envelope, which it would at first exactly fill. But during the further progress of refrigeration, the capacity of the envelope thus formed would, from various circumstances, be diminished.

The first circumstance of diminution, or derangement, would arise from the temperature of the interior of our planet being lowered by a much greater quantity than that on its surface. As a consequence, the continuous contraction of the interior fluid mass would proportionally exceed that of the consolidated exterior coating. This inequality of contraction would oblige the enveloping crust to diminish its capacity in order to accommodate itself to its contained mass, which, by convulsive efforts of approximation and subsidence, it would continue to embrace.

The second conspiring circumstance of derangement would result from the centrifugal force keeping pace in its augmentation with the increased contraction of the globe. A change of figure, or increase of ellipticity in the interior fluid mass would be thus induced, which would be followed by the approximation of the elementary parts of the encircling crust, and their consequent dislocation.

These two circumstances combined, are conceived to have given rise to the various ridges and protuberances which we detect upon the surface of our globe.

But, besides these effects, there are still other important changes which would result from the secular refrigeration of the globe, and its inequality of cooling.

During the continuous process of superficial consolidation to which the interior fluid mass would be subject, gases would no

doubt be formed and extricated, the expansive power of which, where the exterior crust was weak or yielding, would give rise to rents or fissures approaching to a circular form.

But it is doubtful if this force is often singly exerted. The expansive power of confined gases thus generated would conspire with the increased pressure resulting from the diminished capacity of the enveloping crust of the globe, and these, acting in combination upon the interior fluid mass, would overcome its strong resistance to compression, and cause a violent ejection of its substance in the form of lavas, &c.

Lastly, the numerous smaller foramina and fissures induced by various causes of convulsion, would invite the escape through them of gases and vapours generated by the interior fluid mass, which, in their condensation during their ascent, would give rise to various mineral and thermal springs. This liberation would of course cause a diminution of the gaseous charge, which would be continually repaired by newer subterraneous products. And hence, (as the author from whom I have borrowed has remarked,) the permanence of these springs, their almost invariable temperature, and the singular nature of their principles.

These are nearly all the principles which I would intrude upon the reader relative to volcanic theories, for which I am chiefly indebted to the author whom I have cited.

Perhaps it may be expedient to advert to one other theory which may be hazarded, regarding the supposed older character of eruptions of trachyte.

It has been often noticed that in a volcanic district trachytic eruptions are prior to those of basalt.

This very frequent precedence is one of the most remarkable circumstances which geologists have noticed, the cause of which it is difficult, if not impossible, to explain. It probably bears a reference to the deep-seated and internal constitution of our planet, or, in other words, to the mineral nature of the concentric layers which form the interior fluid mass of the globe. If this supposition be admissible, some very recent speculations may throw upon it a faint degree of light. Thus, upon the principle now established, that the consolidation of the exterior crust of the globe is the effect of a gradual cooling, it has been inferred, *first*, That the consolidation of the crust of the globe must have commenced at the surface, and have proceeded towards the interior; and, *secondly*, That beds or layers ought to be arranged nearly in the order of their fusibility.

It is evident, however, that this inference cannot possibly be

applicable to the order of succession in which any rocks are formed resulting from the degraded surface of the earth's crust, although it may serve to explain the relative situation of granite, trachyte, and basalt. Thus, in supposing granite to have been the oldest volcanic matter consolidated, trachyte may be supposed to still subsist beneath granite, as a subjacent stratum of liquified matter, while basaltic matter, in the same liquified state, may occupy a still lower position. Assuming this arrangement, we may easily conceive that during the internal convulsions of our globe, the first extravasated matter protruding from beneath granite would consist of trachyte, while a later eruption would be formed of basaltic matter.

So far the theory becomes plausible enough. But it sometimes happens that this order of eruption is reversed, and that, instead of basalt succeeding to trachyte, basalt actually precedes trachyte, or an alternation of trachyte and basalt ensues. These varied circumstances certainly appear adverse to the theory which I have supposed, though perhaps not fatal to it; as I can easily conceive of such extensive convulsions taking place beneath the solid crust of the globe, as to cause concentric layers of trachyte and basalt to change their relative places, and thus to completely reverse their usual order of eruption.

These few hints upon one of the most striking, yet obscure, incidents in volcanic eruptions are sufficient. I am unwilling to hazard the character of this volume, by filling it more with vague speculations than with plain matters of fact.

But before I conclude these introductory observations, I would observe, that there is another difficulty which awaits the geological aspirant in his volcanic researches, as formidable almost as the conflicting theories which are too often presented to his choice. This consists in the very vague nomenclature which has recently been introduced by systematic writers in their several descriptions of volcanic products.

In fact, no two geologists speak the same language.

During this unsettled state of nomenclature, the geologist will the least err who avoids as much as possible applying any newly-coined titles whatever; but who, in accurately describing the mineralogical characters of the rocks before him, leaves their respective names to be determined when volcanic rocks shall have been better studied, of which the stability of a more generally approved nomenclature will afford the happiest of indications.

But it is expedient to quit these discussions.—While I have endeavoured to make the geological student acquainted with some few of the ultimate principles and theories which are now en-

tertained regarding the volcanic agency, I have, with a view to his practical benefit, cautioned him regarding the many trifling, and worse than useless distinctions which are employed in modern nomenclatures to distinguish volcanic products. It is therefore time to advert to the more immediate object of this memoir, which is the exemplification of such volcanic phenomena as are afforded by a visit to the basin of Neuwied, situated on the Lower Rhine.

The Basin of Neuwied derives its chief interest from the study which it affords of such interesting volcanic phenomena as Humboldt, in his description of the volcanos of Quito, has described under the name of Mud Eruptions,—of which, indeed, an older example is afforded in the eruption of the volcanic mud which overwhelmed the city of Herculaneum. Such phenomena have, I suspect, played a far greater part among the extinct volcanos of Europe than is commonly supposed. In studying, therefore, the tufaceous deposits of the Basin of Neuwied, which are in this locality so perspicuously and instructively displayed, we may, I think, be encouraged to expect that we shall arrive at the solution of other volcanos upon a far grander scale; among which I might enumerate those of the Cantal, of the Mont d'Or, as well as various extinct volcanos of Italy.

In one circumstance, however, there is in the basin of Neuwied a deficiency of instruction. The lava flows are few; they are not large; and their precise points of eruption are too often obscure. To be familiar with these the student must rather transfer his studies to Auvergne, than to the banks of the Rhine.

But, in other respects, the basin of Neuwied presents facilities of instruction which few other spots enjoy. Volcanic craters are displayed in all their varieties, and the distinct characters of trachytic, basaltic, and pumiceous eruptions cannot be better developed. It must be likewise taken into consideration, that all these varied phenomena are comprehended in a narrow space of territory, and at a distance of not more than three or four days journey from the shores of England; for which reason I cannot err in recommending the student of geology, before he adventures to explore the volcanic phenomena of France or of Italy, to avail himself of the preparatory study which the basin of Neuwied invites, with comparatively little inconvenience and toil to its investigator. And I can further promise him, that, if in this crowded cluster of volcanic rocks, he make a profitable use of his time, no future appearances which may present themselves in other volcanic districts will create in his mind any extraordinary degree of embarrassment.

# HISTORY

OF THE

# EXTINCT VOLCANOES

## OF THE BASIN OF NEUWIED, ON THE LOWER RHINE.

The small, yet highly interesting volcanic district to be explained, is situated in the Prussian province of the Lower Rhine, forming a depression, or basin, which is bounded on the north by the hills whence proceed the waters of the Brühl, and on the south by those which give rise to the Nette; each of these streams joining the Rhine, the former near the village of Brühl, celebrated for its trass-quarries, and the latter about three miles to the south-east of the ancient city of Andernach. Its extent may be estimated at about twenty-four miles from east to west, and at six to ten miles from north to south. *(See the general Map.)*

## CHAPTER I.

### THE PRIMARY FORMATIONS OF THIS DISTRICT.

Argillaceous schist, or clay-slate, the *Phyllade* of the French, and the *Thonschiefer* of the Germans, is found spread over the whole of the district under consideration, constituting the lowest visible strata, and differing little from what is observed in most primary or transition formations. It is of a bluish-grey colour. Small scales of mica are occasionally disseminated in it, but always very sparingly, and it is in many places traversed by veins of quartz.

An arenaceous character is not unfrequently assumed, particularly by the upper strata; and, as in this state they contain much ferruginous matter, the colour becomes of a reddish or yellowish brown. This modification of the rock, which is observable at Kelberg, at The High Acht, in the neighbourhood of Virneberg, near Coblentz, and in other sites, is remarkable for the marine remains which it contains. Some of the species enumerated by geologists

are the *Spirifer alatus* and *sarcinulatus*, which are found near Coblentz.

In the internal structure of this formation, which is generally fissile, there is little to remark. In one locality a striking peculiarity has been noticed. In a quarry on the northern extremity of the fortress of Ehrenbreitstein, the rock, which is a fine-grained grauwacke, occasionally assumes the structure of basalt, being separable into balls from half a foot to two feet in diameter, of which the largest size is the most plentiful. These balls are in general so perfectly rounded as to appear the produce of art; a few only being slightly compressed. In their interior they are of a very firm consistence, but near their surface, owing to the diffusion of the oxy-hydrate of iron, they peel off into concentric scales. (*See Noeggerath's Rheinland-Westphalen*, vol. iv. p. 362.)

The direction of these strata is various. A frequent line of bearing is from about S. 35° W. to N. 35° E. The angle of inclination is no less inconstant. A dip to the east of about 60° or 70°, may perhaps be cited as one that is often observable. Near Coblentz it is from 75° to 90°.

In very few localities is this clay-slate metalliferous. Iron is procured from it in the form of an oxide, between Coblentz and Bendorf, and at Namedy the rock is wrought for the thin veins, or gangues, which it contains, of the oxide or green carbonate of copper.

But it may now be added, that although no primary or transition strata, except those which have been enumerated, are exposed in the deepest sections or escarpments of this district, we possess a perfect knowledge of even lower rocks. We find entangled in the lava, which has issued from volcanoes of a far later period, fragments, often more or less altered by heat, of the several rocks through which igneous products, whether in the form of lava, cinders, or pumice, have forced for themselves an exit. For example, highly crystalline strata of mica-slate, gneiss and granite, which last we may presume to be the lowest in the series, may be detected among the ejected fragments of these eruptions. And thus, by a truly Plutonic source of information, we are actually apprized of a more early succession of rocks than is manifested by such superficial strata as are evident, and which perhaps under no other circumstances would have encountered human scrutiny;—we are apprized that the sequence of rocks, in the district we are examining, consists of, 1*st*, granite, which is the lowest of the whole, being next to the volcanic focus; 2*dly*, gneiss; 3*dly*, mica-slate; and, 4*thly*, clay-slate and grauwacke slate, containing in some localities marine shells.

These ejected fragments will be described when the volcanoes are explained to which they have owed their manifestation.

## CHAPTER II.

A GLANCE AT THE GENERAL HISTORY OF THE SLATE-MOUNTAINS OF THE RHEINLAND PREVIOUS TO THE COMMENCEMENT OF TERTIARY DEPOSITS.

As it may be occasionally found difficult to explain the limited district under consideration apart from that of the whole of the Rheinland, a rapid glance may be taken at the consecutive disturbances to which its mountains have been subjected.

It was explained in the last chapter, that the trifling patch of territory which we are contemplating, bounded by the streams of the Nette and the Brühl, consists of argillaceous schist, or clay-slate, and grauwacke schist. It forms the diminutive central portion of a widely extended formation of clay-slate, which includes the rocks of the Westerwald, of the Eifel, of the Hundsruck, of the Taunus, and of the Ardennes. The cities of Tournay, Namur, Liege, Aix-la-Chapelle, Bonn, Dusseldorf, Dortmund and Paderborn, are situated on the north of its irregular bounding line; Waldeck, (near Cassel) and Hanau, are on the east of it; Francfort, Mayence, Kreutznach, the district of the Saar, Treves, Wittlich and Mezieres lie to the south, while the westerly limit stretches in a north-westerly direction from the vicinity of the last mentioned site to Tournay. From east to west it includes a distance of not less than 250 English miles, and in an opposite direction, from north to south, of 70 to 140 miles, A suspicion even arises that the same formation is continued beneath several secondary deposits as far south as the mountains of the Vosges and Schwartzwald, or even much farther.

As these strata exhibit in many sites, by the various marine remains which they contain, evidence of their formation beneath a deep ocean, a question which arises is,—At what period or successive periods were they first elevated above the level of the sea?

It may, I believe, be shewn that the elevation of the slate-mountains of the Rhine was not the result of one, but of many, consecutive throes or convulsions; that it commenced during an early period, when strata of an intermediate or transition class were in the act of being formed, and was continued at intervals so as to keep pace with the process by which newer secondary deposits arose in succession, each differing from its predecessor in its geological character. The elucidation of this obscure department of our history has recently been attempted by an eminent geologist, M. Elie de Beaumont, to whose doctrine we may now advert.

It may be considered as having been long the notion of some geologists, that, amidst the protracted series of tranquil periods which the surface of the globe has undergone, each was separated from that which followed it by a sudden and violent convulsion, in which a portion of the earth's surface was dislocated or elevated into the form of ridges having different directions. The great and primary cause of these elevations, which has often been referred to volcanic action alone, is now attributed by M. Elie de Beaumont, in correspondence with the views of M. M. Fourier and Cordier, to secular refrigeration.

In the introductory pages of this work, the theory of these philosophers has been cited, and to this explanation of it, although a brief one, I would refer.

" In a given time," to use the language of the French geologist, " the temperature of the interior of our planet is lowered by a much greater quantity than that on its surface, of which the refrigeration is now nearly insensible; and analogy would lead us to consider that this inequality of cooling would place its crust under the necessity of continually diminishing its capacity, notwithstanding the nearly rigorous constancy of its temperature, in order that it should not cease to embrace its internal mass exactly, the temperature of which diminishes sensibly. Our planet must therefore depart in a slight and progressive manner from the spheroidal figure proper to it, and correspond to a maximum of capacity; while the gradually increasing tendency to revert to that figure, whether it acts alone, or whether it combines with other internal causes of change which the planets may contain, may, with great probability, completely account for the ridges and protuberances which have been formed at intervals on the external crust of the earth." (*See De la Beche's Geological Manual*, p. 501, *and the Philosophical Magazine, New Series*, vol. x. p. 241 to 264.)

Such is the theory which M. de Beaumont recommends. It is founded upon the relation subsisting between the advanced refrigeration of our planet, the capacity of its solid crust, and the volume of its internal mass. And, however disposed we may be to admit the legitimacy of its main principle, he has attempted its elucidation less by a few well-established or incontrovertible facts, than by a series of hasty and doubtful generalizations, which would require a century or more of continued geological observations to prove or disprove. Thus, he has confined the successive mountain elevations to which the crust of the globe has been subject to twelve; although it becomes a far more plausible question, whether such disturbing causes have not been far more numerous? He has boldly maintained that a general parallelism subsists among the chains of mountains which were contemporaneously elevated, and that this parallelism was continued in straight lines. Other

observers, however, are inclined to doubt the truth of this hypothetical parallelism, while they think it far more probable that the direction of mountain ridges is not necessarily continued in straight lines, but that it may have often assumed a curved, undulating, or even a radiating direction. *(Journal de Geologie par A. Boué*, tome iii. p. 338 to 359.)

These are the chief difficulties which present themselves in shaping our investigations agreeably to the views of the French geologist. Considering, therefore, our very imperfect knowledge of the actual succession, direction, or extent of contemporaneously elevated chains of mountains, the theory demands in its application the utmost caution and prudence.

For instance, in regard to the Rheinland, M. de Beaumont has conceived that forces of elevation have acted on a line of direction extending from nearly S. 15° W. to N. 15° E. This is a supposition which is far too sweeping and unlimited. The philosopher ought rather to have contented himself with remarking, that such a direction was exemplified in a single instance of disturbances, namely, in the great fracture or fault antecedent to the deposit of the grès bigarré in the basin of Alsace, by which the Vosges and the Schwartzwald were made to form two groupes of mountains parallel to the course of the Rhine. To other convulsions, however, with which the slate-mountains of the Rheinland has been visited, one common line of direction will, I am persuaded, fail in being applicable. The limited district under our examination, bounded by the streams of the Nette and the Brühl, would show how perfectly unavailable are these conjectural views. And in a similar predicament are many other districts of the Rhine which I have examined.

During the long geological period characterized by deposits of the transition or secondary class of rocks, the slate-mountains of the Rheinland appear to have experienced at least six or seven general catastrophes, though it remains yet to be shown whether certain of these are not rather to be considered as the result of a continued series of shocks, than as single efforts of nature. There can be little doubt but that each of these modes of action has in turns prevailed. It is also questionable whether the elevation of one district of the Rheinland has not produced a depression in another; whence the alternation of marine and fluviatile deposits which in some few sites are discoverable.

But notwithstanding the doubts which have arisen in the minds of many geologists regarding the validity of various tenets taught in M. Elie de Beaumont's general system, I am still disposed, in the absence of any other similar researches, to adopt, though with much qualification, his enumeration of the epochs when very extensive catastrophes altered the surface of the globe;—notwith-

standing even my suspicion that such catastrophes will eventually be found to have been far more numerous. It is, at the same time, my opinion, that the slate-mountains of the Rheinland have been more or less affected by nearly all the convulsions which have at different intervals disturbed the solid strata of Europe. These disturbances, therefore, with the aid, though certainly a faint one, of the guide whom I have cited, (for such investigations are at present in their perfect infancy,) I shall now endeavour to enumerate.

(*a.*) *The convulsion or convulsions followed by the more recent transition strata, and by carboniferous strata.*

The period when the slate-mountains of the Rhine first became raised above the surface of primeval waters, may be referred to the most ancient of the epochs of M. Elie de Beaumont. He has conceived that there has been a disturbance of strata prior to the more recent of those which he has named *Transition*. In supposing the correctness of this view, and there is perhaps no reason to doubt it, it may, I think, be shewn, that an elevation of one or more of the districts of the Rheinland took place before the deposit of the transition limestone of the Eifel, which contains a profusion of shells, corallines and trilobites.

But it is added, that by a subsequent convulsion, the dislocation of the argillaceous schists of transition, and the grauwackes of the environs of Villé and Beauchamps in the Vosges, was followed by the deposit of the *systéme houiller*;—a system which comprehends the carboniferous limestone and the old red sandstone. Coal measures, as he adds, repose upon the edges of the tilted rocks of the Vosges, while the carboniferous rocks of Belgium and Saarbruck were deposited at the foot of the Eifel, Hundsruck, &c. *

(*b.*) *The convulsion which was followed by the deposition of the Grès Bigarré, the Muschelkalk, and the variegated Marls.*

A third disturbance had its chief seat in the upper Rheinland.

* "The Rhine from Bingen to Coblentz," observes M. Elie de Beaumont, "traverses a system of mountains, of which the Hundsruck and the Ardennes form a part, and which M. Leopold de Buch has named *Systéme des Pays-Bas*. This system is composed principally of beds of argillaceous schist, grauwacke, calcaire, and grès houiller, directed nearly E. N. E. to W. S. W., and comprehends the inclined beds of the coal formation of the environs of Sarrebruck, upon the escarpment of which the beds of the Grès des Vosges are nearly horizontally extended. This last circumstance affords evidence, that the elevation of the beds of this system took place between the period of the deposit of the terrain houiller and that of the Grès des Vosges." —(*Annales des Sciences Naturelles*, tome xviii. p. 313.)

The Vosges and the Schwarzwald terminate opposite to each other in two long cliffs parallel to the course of the Rhine. These, says M. Elie de Beaumont, are apparently due to two great faults which have a direction from S. 15° W. to N. 15° E.; which fractures preceded the deposit of the rocks in the basin of Alsace, among which are the red or variegated sandstone, (*grès bigarré*,) the muschelkalk, and the marnes irisées or variegated marls. The same deposit we also observe at the foot of the slate-mountains from Prum in the Eifel to Treves and the vicinity of Kreutznach, and even to the west of the Vosges. *

(*c.*) *The convulsion which was followed by the deposition of the Oolitic series of rocks.*

The particular convulsion which affected the strata immediately antecedent in date to the oolitic series of rocks is not distinctly shewn. It was the forerunner of a very extensive deposit of the lias and oolites, which may be found to the south of the Ardennes, or, easterly, from the west of the Harz mountains to the Jura.

(*d.*) *The convulsion which was followed by the deposition of the lower cretaceous strata, namely, the green sand and chalk.*

A convulsion which is supposed to have given rise to the elevated system of rocks, which M. de Beaumont has designated by the name of the system of the Pilas, the Cote d'Or and the Erzegebirge, has been conceived by him to have been one of the chief causes of the disturbed strata of the Rhine, which it has elevated in a direction from S. W. to N. E. "It must not be forgotten," says this geologist, "that the strata of these countries have had accidents caused in them subsequently to the convulsion which gave rise to the system of the Erzegebirge, the Cote d'Or, and the Pilas. It is without doubt in consequence of this circumstance, that the grès bigarré and the muschelkalk are found dislocated in some points of the great ridge of hill, (falaise,) of

* "The beds of the Grès de Vosges," says the geologist whom I have quoted, "which compose the long *falaise*, (line of hill,) which borders the plain of the Rhine, from the environs of Thann to those of Landau, are not observed to be crowned in any point by the beds of the grès bigarré and muschelkalk that are so often observed at its base. It is natural, therefore, to suppose, that this same line of hill, (*falaise,*) has overtopped by nearly the whole of its actual height, the level of the water, below which were deposited the grès bigarré and the muschelkalk. It appears, according to this, that the fault which has given rise to it was produced between the period of the deposit of the grès des Vosges and that of the deposit of the grès bigarré. Such is then the date of the terrestrial events which characterize the system which M. Leopold de Buch has named the *System of the Rhine,* and of which the long ridge of hills of which I have just spoken, forms a part."—*Annales des Sciences Naturelles,* tome xviii. p. 313.

the Grès de Vosges." This admission which is made, would lead to the inference, that the deposition of the grès bigarré and muschelkalk had been continued down to the oolitic period. It is more probable, however, that a convulsion which supervened to the oolitic formation, or in which the strata were disturbed up to the oolitic rocks inclusive, gave rise to the green sand and chalk which we find in the neighbourhood of Dusseldorf, Aix-la-Chapelle or Maestricht.

(*e.*) *The convulsion which is said to have been followed by the deposition of the upper beds of the Cretaceous system.*

It is supposed that in a late period of the secondary epoch, another immense elevating power in Europe exerted its influence, which, in upheaving not only the older secondary rocks, but also the newer ones, such as the earlier members of the Wealden formation, the green sand and chalk, prepared the way for the deposition of such upper beds of the cretaceous system as are distinguished by the presence of nummulites, cerithia, ampullariæ, and other shells. By this convulsion the French Alps and the south-west extremity of the Jura are said to present a series of ridges and dislocations in a direction towards the N. N. W.; the eastern crests of the Devolny, north from Gap, being raised more than 4700 English feet above the level of the sea.

That this event affected the slate-mountains of the Rhine we have no proof. We are perfectly justified in suspecting that the cessation of the chalk deposit at the foot of the slate-mountains near Maestricht, was the effect of some disturbance, by which the older rocks were upheaved; but it is not quite evident whether the catastrophe was not of a later date, or whether it did not take place during an early period of the tertiary deposits.

(*f.*) *The convulsion which is supposed to have been followed by the earlier tertiary strata.*

M. Elie de Beaumont has supposed that one of the earliest convulsions of the tertiary epoch had its date in a period when the whole chain of the Pyrenees sustained a considerable elevation, as well as the northern and some other ridges of the Apennines, the calcareous chains of the north-east of the Adriatic, those of the Morea, nearly the whole Carpathian chain, and a great series of inequalities continued from that chain through the north-east escarpment of the Harz mountains to Northern Germany. The general direction of the system of elevated chains thus induced is said to have been from E. S. E. to W. N. W.; but upon this conclusion I only need repeat what I have more than once remarked, that much reasonable doubt may be entertained.

It has been affirmed that by this convulsion strata of the age

of the green sand and chalk were ruptured and contorted, and often lifted up to the very pinnacles of the mountains; and that deposits of the tertiary class then began to approach the confines of this system, and to assume a horizontal position.

Here, then, we will pause on the presumption, that whether the mountains of the Rhine partook of this catastrophe or not, new tertiary deposits began about this period to occupy its vallies, the history of which will form a particular object of our future investigations.

These are the earlier disturbances to which the slate-mountains of the Rhine appear to have been subjected. And it forms a question of curious speculation, What must be the general state of the lands of Europe during such convulsions?

M. Boué, in a history given by him of a great Mediterranean sea which he has shewn to exist in Europe at the close of the secondary, or commencement of the tertiary epoch, and which most probably had its origin in very ancient depressions, states that it communicated with the seas of the north, with the western ocean, and, through the medium of one or two channels, with the *present* Mediterranean Sea. (*Journal de Geologie,* tome iii.) These views carry with them much weight, and I am inclined to believe, that during such a condition of the globe, the slate-mountains of the Rhine must have formed one, or perhaps more islands, rising abruptly from the surface of these ancient pelagic waters;—an inference which is readily suggested by the various and successive marine deposits which we trace at the foot of the Ardennes, the Westerwald, the Taunus, the Hundsruck, or the Eifel.

## CHAPTER III.

### THE ANCIENT VALLIES OF AN ELONGATED FORM CONNECTED WITH THE BASIN OF NEUWIED.

The inquiry of the preceding chapter referred to the state of the slate-mountains of the Rhine in general, during an immense epoch ending with the period when tertiary deposits first dated their existence. This consideration will prepare us to investigate the effects which these disturbances must have had on the limited district to which our attention is intended to be more particularly directed. The great result would certainly be, that its solid strata would be shaken to their very foundation, while, during their very forcible elevation, deep fissures, or, according to a late phra-

seology, deep vallies of disruption, (*vallées d'ecartement,*) would ensue. These we shall now consider.

A valley of fracture or disruption (*vallée d'ecartement*) has been described by M. Omalius D'Halloy after the following manner: "It is evident," says this geologist, (*Journal de Geologie, par A. Boué,* tome ii. p. 402,) "that when a mass of cohering rocks has been very forcibly uplifted, it ought not only to be cleft at a great number of points, but its parts ought to separate and remove from each other; consequently, there ought to result fissures or hollows, bounded by precipitous escarpments. * We may also conceive on this system of separation, why the flanks of a valley should present a salient angle before a re-entering angle; and why they should be formed by the same beds disposed in the same order, since these flanks are often nothing more than the walls of a fissure induced in an uniform mass."

The study of the direction of these vallies of disruption or fracture is of no little moment, particularly when we reflect that such fractures are often found parallel to the elevated crests of mountain chains; while the important connection of these lines of fissure with volcanic eruptions becomes a subject of future consideration.

Such being the effects connected with the elevation which rocks have at different intervals undergone, we ought consequently to expect, that the deep vallies which the slate-mountains of the Rheinland now exhibit, might have had a date of origin so far remote, as to be referable to an elevation of land immediately following depositions of the transition class of rocks, or coëval with strata of the grès houiller, or indeed of any later formation; in which case, owing to the attriting action of torrents continued in such fissures during an incalculable period of time, it would not be always easy to distinguish such appearances as have originated amidst the convulsive effects of uplifting causes, from those which have been caused during an incalculable lapse of ages by the persisting degradation of meteoric agents.

This difficulty attends the examination of most of the vallies connected with the limited district of the Lower Rhine, which is bounded by the Nette and the Brühl. Without further preface, therefore, we shall now consider them in their order.

*The vallies which have the direction of S. W. and N. E., or of S. W. by W. and N. E. by E.*

I am inclined to think that the most ancient lines of elevation

* M. Omalius d'Halloy adds, that if the elevating cause has acted upon moveable masses, the subsidence will not permit the fissures to establish themselves; which explains why water courses traverse elevated mountains, and turn back before small sandy projections.

which were assumed by the mountains of this district, as well as the fissures which were the concomitant of these convulsions, may be exemplified (first,) in the valley of the Moselle, and (secondly,) in the valley which bounds the west of the Nurburgh and the Hohe Acht. In fact, these fissures appear to be of such an inappreciable antiquity, that it is no extravagant conjecture that they might have had their commencement with some of the earliest elevations of the Rhenish slate-mountains above the surface of a primeval sea.

THE VALLEY OF THE MOSELLE.—Of the valley of the Moselle little need be said, as it has no connection with the present district, except what is observable at Coblentz in its confluence with the Rhine. It is sufficient to make the general remark, that, in its precipitous banks and other circumstances, it exhibits, particularly in the vicinity of Berncastle, the close resemblance of a deep fissure or split induced during the first great elevation and forcible division of the mountains of the Hundsruck and the Eifel. Its direction is very nearly from S. W. to N. E.

THE BOUNDING VALLEY TO THE WEST OF THE NURBURG AND THE HOHE ACHT.—The Nurburgh and the Hohe Acht are two lofty hills of the Eifel, which form the westerly limits of our district; the first of these, according to M. Umpfenbach of Coblentz, attaining an elevation of 2220 Rhenish feet above the level of the sea, while the height of the latter (the Hohe Acht) is estimated at 2434 feet.

As I have hinted that there is reason to suppose that the lofty district of the Eifel was one of the portions of the slate-rocks of the Rhine which was the first elevated, we are entitled to demand that these claims of superior antiquity be supported by the profundity of its vallies, which ought to be commensurate with their exposure for countless ages to the persevering action of mountain torrents. Nor in this expectation will the geologist be disappointed. It is impossible to conceive of a country where, in proportion to the height of its hills, more numerous vallies, or ravines of more remarkable depth may be observed. Bold escarpments are everywhere visible, and as the corroding action of waters has been exerted upon cliffs varying in their quality and firmness of structure, and in their consequent proneness to decomposition, the sides of the vallies appear worn into protuberances or cavities of the wildest and most grotesque form.

*The Vallies which have a direction nearly West and East.*

Two vallies of great antiquity, yet perhaps not so old as the last cited, have a direction nearly west and east. These are (first,) the valley of the Brühl, and (secondly,) of the Nette.

THE ANCIENT VALLEY OF THE RIVER BRUHL, EXTENDING

From Hahnenbach to the present site of Burg Bruhl.—A very ancient ravine of great profundity takes its rise from the high hill of Hahnenbach, and assuming in its course a direction of nearly east and west, was originally extended for a distance of nine miles as far as the present site of Burg Brühl, where it was abruptly terminated. Here a very small lake was naturally formed, the overflow of which drained off towards the course of the Rhine.

But while this valley is entitled to the character of a fissure of disruption, we must withhold this claim from the numerous lateral vallies, which, in conducting the waters from contiguous hills, join the channel of the Brühl. These have probably been wholly or in a great measure produced by the gradual corrosion which has been continued during an interminable period. They naturally run in miscellaneous and independent directions, namely, from south to north, or from south by west to north by east.

The ancient valley of the Nette from the Nurburg to the Carmelenberg.—Another very ancient water-course corresponding with the last described, may be traced in a di-direction nearly east and west from the high hill of the Nurburg to the Carmelenberg, a distance of twenty miles or more, where it originally became lost in the deep depression or basin of Neuwied. It now affords a channel for the stream of the Nette, which, in consequence of later changes, (remaining to be described in a more advanced stage of our history,) is prolonged from its earliest termination in a different direction, until it joins the Rhine opposite Neuwied. This ravine by its depth, by its precipitous escarpments, and by its salient and re-entering angles, shews indubitable marks of great antiquity, and is fully entitled to the character of a valley of disruption.

*The Vallies which have the direction of N. W. and S. E.*

The vallies of disruption which are included under this head, consist of (first,) the lateral vallies which join the channel of the Nette, and (secondly,) a considerable portion of the valley of the Lower Rhine.

The lateral vallies which join the Nette.—It is difficult to assign to certain lateral vallies which join the channel of the Nette exactly the same origin as to those which are similarly connected with the Brühl. Their direction is from N. 40°, W. to S. 40° E. That they were originally induced by the causes of elevation which we have described is highly probable, and more particularly so, when we take into consideration their number and general parallelism. A suspicion also arises that they are of comparatively a later date, which is countenanced by the circumstance, that the course of these fissures is terminated at the points where

they respectively meet the valley of the Nette. But whether this origin be legitimately assignable to them or not, it must be still kept in view that their extraordinary depth would be promoted by the long wear, continued perhaps during a long tertiary epoch, of mountain torrents.

The first set of parallel vallies, amounting to three or four in number, take their rise from the tract of high land in the vicinity of the Nurburg and Hohe Acht. They form the deep water-courses of rapid streams, and, owing to the salient and re-entering angles which they exhibit, appear to run a zigzag course, although they still preserve their general direction of N. 40° W. to S. 40° E. As the channels of subsidiary currents, they there join the Nette.

But the valley which, from its greater length, appears of the most determinate character, is that which we trace in the same parallel direction from the heights of Leimbach and Kempenich, for a distance of eleven or twelve miles, to the south of the town of Mayen on the river Nette. This valley, the original form of which is in some few places obscured by later changes of a volcanic nature, exhibits a deep ravine, remarkable for the boldness of its salient and re-entering angles, which can scarcely fail to entitle it to a place among unequivocal vallies of disruption.

Part of the Course of the Lower Rhine.—Again, if we contemplate that part of the course of the Rhine which intersects the present district, namely, that which we trace from the gorge of Andernach to Rheineck Castle, we shall still find that the same identical line of S. E. and N. W. is carefully preserved. And as this direction corresponds with that which the Lower Rhine has continued to preserve from Bingen to Cologne, it is not unreasonable to suppose that it was affected by the same common convulsion to which I have attributed the formation of four or five parallel and adjacent vallies, situated on the west of this broader fissure.

It is not, however, a new suspicion, that the valley of the Rhine, as far even as from Bingen to Bonn, was originally an immense fissure, suddenly induced by causes of violence. At the same time it must be admitted, that, in many places, the steepness or precipitation of its banks, as well as its salient and re-entering angles, have been much obliterated by the undermining action of the river, for which it has served as a canal through countless periods. Hence the sort of mixed character which the channel of the Rhine exhibits. While we refer its first formation to distant convulsions, we trace in other appearances the deepening action of long-continued mountain streams.

With the particular nature of the great catastrophe connected with the formation of the valley of the Lower Rhine, there is necessarily

the greatest mystery. It was probably induced during some elevation of the ranges of mountains which on the west form the Hundsruck and the Eifel, and on the east the Taunus and the Westerwald. And should this speculation be ever rendered susceptible of proof, it may perhaps be shewn, that the points at which the uplifted rocks began to be cleft are referable to the site of the Loch of Bingen, and to that of the gorge of Andernach. From the former we trace a fissured line extending to Coblentz, where it is lost in the expanse intervening between the elevated and receding ridges of the Eifel and the Westerwald. The line was evidently renewed a little below the ancient barrier of this expanse or basin, near the present city of Andernach, whence it was prolonged with some intermissions through ranges of slate hills, until it reached a lower lake, distinguished by the present sites of Bonn and Cologne.

The exact period when the valley of the Lower Rhine from the Loch of Bingen as far north as Bonn began to be formed, though conjectured to have occurred during the middle of the secondary period, is still involved in the greatest obscurity. There is no indication of any deposit which might have taken place in it during the immense interval of time occurring between the formation of the primary argillaceous schist and the latest secondary strata. If any such did exist, we must attribute its disappearance to causes of degradation, which, there is no doubt, have utterly removed many such deposits in various parts of the globe, and transported them to fill up distant seas and lakes.

These remarks conclude my account of the antiquity of the elongated vallies of disruption connected with the basin of Neuwied.

The most ancient of them, which probably were coëval with the first elevation of the Eifel, have been shewn to run from about S. W. to N. E, or from S. W. by W. to N. E. by E. which is the direction of the channel of the Moselle, and of the valley west of the Nurburg and the Hohe Acht.

The next to all appearance in point of antiquity have a course from west to east, which is the direction of the channels of the Brühl and the Nette;—while

The third and more numerous set it is of chief importance to keep in view, as they are parallel to the channel of the Rhine, which is likewise to be considered as a valley of disruption. By these parallel vallies, which run from N. W. to S. E. the whole of the district which we are examining has been intersected. And it is essential to add, that, with few exceptions, subsequent volcanic eruptions have conformed to this common line of direction.

## CHAPTER IV.

### THE STATE OF THE RHEINLAND AT THE COMMENCEMENT OF THE TERTIARY EPOCH.

An explanation having been rendered of the different elevations and fissures which were antecedent to the tertiary epoch, our next object is to point out the general result, preparatory to a long interval characterized by various lacustrine deposits. This will be described in connection with the recent and valuable speculations of M. Boué on the tertiary basins of the north of the Alps.—(*Journal de Geologie*, tome iii.)

It has been supposed, that before the deposition of the molasse of the Continent, the marine waters, which flowed over much of the present soil of Europe, had their connection with the main ocean cut off; that a large inland sea existed to the north of the Alps, which extended from Savoy to the Bannat, while on the north it was separated from the Baltic by the Carpathian range of mountains *; that promontories of great magnitude, by which its bounding line was characterized, rendered its contour very sinuous, or otherwise diversified; and that numerous isles rose from its surface, particularly near its margin.

Amidst these irregularities, our inland sea is conceived to have been divided into a number of basins, estimated by M. Boué at six or seven, which he has designated by the names of Hungarian, Austrian, Suabian, Bavarian, Swiss, or Rhenish basins; which basins were nearly isolated, as their communication with each other only subsisted by means of straitened channels. Currents played among them, which were ultimately directed towards the two greatest inland depots of marine waters, still recognized in the sites of the present seas which bound the south and south-east of Europe. While an overflow into the Mediterranean sea may be traced near Chamberry and Grenoble, another into the Euxine must have occurred near the Bannat.

The comparative height of these waters, when compared with each other, or with the level of the ocean which then subsisted, cannot fail, owing to subsequent elevations of the land, to be of difficult estimation. It is imagined, that the Atlantic had at this time approached its present level.

After this very general summary of a portion of M. Boué's observations, we shall be prepared, in reference to them, to consider

* The elevation of this range, according to M. Elie de Beaumont, was one of the first convulsive events of the tertiary period.

the tertiary geography of the Rheinland. I shall therefore describe in succession, *1st,* The marine basin from Mayence to Basle; *2dly,* The fissured channel of the Lower Rhine between Bingen and the basin of Neuwied; *3dly,* The Upper fresh-water basin of Neuwied; *4thly,* The channels by which the overflows of the basin of Neuwied were discharged; and, *5thly,* The Lower fresh-water basin of Cologne.

Explanatory of this description, the following ideal map of the tertiary state of the Rheinland is annexed.

SKETCH ILLUSTRATIVE OF THE TERTIARY GEOGRAPHY OF THE LOWER RHEINLAND.


### *1st, The Marine Basin from Mayence to Basle.*

The valley from Mayence to Basle has been properly regarded by M. Boué as one of the ancient marine basins of Europe during the tertiary period. In consequence of a barrier of high land stretching across the present site of the straits of Bingen, and thus filling up the small geographical space intervening between the chains of the Hundsruck and the Taunus, this marine basin had no connection with the present channel of the Rhine from Bingen to Cologne, or farther north. Its waters flowed in a direction quite opposite to that which they now maintain, being from north to south, while its southerly extremity was connected with the other marine basins of Europe by means of narrow channels.

M. Boué has supposed, that upon the commencement of the formation of the molasse, or blue-clay, of which the deposit of the basin of the Upper Rhine may be considered as an equivalent, all the

intermediary and secondary formations of the Alps had begun to suffer great waste and destruction. Owing, as he adds, to the difference of climate at that time, the waters poured upon the earth must have been so immense, that the debacles of modern lakes and the excavations of equatorial rivers would convey a faint idea of their effects. As the declivity of the beds, or of the torrents by which they were scooped, would be much greater than at the present day, enormous masses of debris ought to be accumulated in the vallies beneath the tops of mountains. This accumulation would again be aided by the frequent discharge of the contents of the numerous fresh water lakes contiguous to these marine basins. Thus, for instance, in the basin of Mayence, we have fluviatile shells, such as Planorbes, Lymneæ, Paludinæ, or Neritinæ, mingling themselves in the same calcareous or sandstone beds with the Trochus, the Cerithium, the Ostrea, the Mytilus, the Pectunculus, the Murex, the Fusus, the Conus, and many others; or, again,—we have the same fluviatile shells, not indiscriminately mingling, but alternating with marine products, as might be expected from some fresh water lake in the vicinity which observed a periodical overflow.—(For the latest list of shells of the marine basin of the Rhine, see the *Geognistisches Gemälde von Deutschland von A. Boué*, pages 382 and 578.)

Into farther details it is not necessary for our present inquiry to enter.

*2dly, The fissured channel of the Lower Rhine between Bingen and the Basin of Neuwied.*

It has been explained, that during some elevation of the Rheinland, probably of the chains of the Hundsruck and the Taunus, an intermediate fissure or valley of disruption was the result. This prolonged rent commenced near the present site of Bingen, and was continued in a northerly direction as far as that of Coblentz, where the fresh water basin of Neuwied commenced. Thus becoming a deep water course, subsequent mountain torrents would gradually widen it, and smooth down many of its original asperities.

It was also shown in the last section, that, owing to the intervention of a narrow mountain ridge, this fissured channel had originally no communication with the marine basin of Mayence.

*3dly, The Upper Fresh-water Basin of Neuwied.*

The basin of Neuwied, which is so named from the town in the centre of it, appears to have owed its origin to the forces which at distinct points were employed in elevating the nearly parallel ranges of mountains named the Eifel and the Westerwald, to which the depression is intermediate. It has no claims to the character of

a valley of disruption, as it is not marked by precipitous but by gradually sloping banks. Its geographical limits are as follows:

If we would commence our observations from the fortress of Ehrenbreitstein, near Coblentz, where the Rhine has forced for itself a channel through steep rocks, we shall find that the bounding line of the basin made a northerly sweep by the high land of Kreutzkirch to Andernach, where originally no gorge existed, and thence in a direction west by south, until it reached the site of the Laacher-see, whence it was continued nearly due south to the present site of Mayen. From this last place the line was conducted east to the point whence we first set out.

This basin is from sixteen to eighteen miles from east to west, and from four to seven from north to south. The elevation of its waters was scarcely less than about one thousand feet above the level of the sea, even after making some allowance for subsequent derangements.

The Neuwied depression was originally fed by many streams, of which the Rhine can scarcely be affirmed to have been the principal. Before this ancient fissure of disruption became lost in the expanse of lake we are exploring, it was joined by the stream of the Lahn, which drained a considerable portion of the heights of the Westerwald and the Taunus. Another river was the Moselle, which was then of far greater importance than the Rhine, deriving its waters from a southerly origin far more remote, the ancient bed of which, where it was lost in the lake of Neuwied, being still observable in the high ground to the west of the peak of the Carmelenberg.

A third contributing stream, though a feeble one, to the contents of this basin, conveyed the overflowings of a small adjacent mountain lake, not more than $2\frac{1}{2}$ miles in diameter, which was confined by the high lands of Boos, the hills north of Kelberg, the Nurburgh, and the hills west of Virneberg. To the current which drained this reservoir was added another, which, in rising from the Leimbach and the heights of Kempenich, became mingled to the west of Mayen in the common channel of the Nette.

A fourth source of the waters which contributed to the basin of Neuwied, was the range of hills named the Westerwald, whence issued small corroding streams which are now collected in the common channel of the Wied.

The general nature of the formation which began to occupy this basin may be summed up in a few words: it consisted of beds of fine sand and of plastic-clay.

The origin of this deposit can scarcely be a mysterious one. It is natural to look for the transportation of it to the rivers by which

the basin of Neuwied was fed;—which origin (infinitely the most simple one to comprehend,) is, if possible, rendered more plausible by the indications which the plastic-clay, the fine quartzose particles of the sand and their diffused scales of mica afford, of their having been derived from a primary class of rocks, consisting of such as are the most frequent in the Rheinland, namely, of clay-slate or grauwacke schist, traversed by veins of quartz.

This deposit will be described in detail when I come to treat of the period in which it appears to have been completed.

*4thly, The channels by which the overflow of the Basin of Neuwied was discharged.*

In the last section it was hinted, that the present gorge of the valley of Neuwied, situated close to the city of Andernach, did not at one time exist; in the place of which a barrier of continuous cliff rose to a considerable elevation, of not less, perhaps, (judging from the height which the lacustrine waters of the basin had attained,) than a thousand feet.

The channel of the Rhine from Andernach to Linz, a distance of about fourteen miles, appears, like that from Bingen to Coblentz, to have owed its earliest direction and form to a fissure of disruption induced by convulsive operations, which was no doubt subsequently widened, or otherwise modified, by its becoming a deep water-course, by which an overflow from the ancient lake of Neuwied was conveyed to the lower fresh water basin of Cologne. This overflow, for a distance of one or two miles north of Andernach, a space intermediate to the basin of Neuwied and the fissured channel of the Rhine, must have been originally precipitated in the form of a cataract.

But this was not the only drainage of the waters of the lake of Neuwied. Another must have occurred three miles to the north of Andernach, through the medium of the fissured channel of the Brühl, which even at the present day conveys the waters which are collected from the north and north-westerly heights of the Laacher-see to the common channel of the Rhine. But as this fissured channel was probably a remote effect of the volcanic eruptions which in this district distinguished the commencement of the tertiary epoch, it will be more particularly described in the ensuing chapter.

*5thly, The Lower Fresh water Basin of Cologne.*

In tracing the Rhine between Linz and Bonn in its descent, it is rather difficult to state at what exact point this lower fresh water basin may be said to have its commencement. A widening of the channel of the Rhine commences near Linz, about the confluence of the river Ahr, where indications of a tertiary lacustrine deposit

begin to be manifested. But for a distance of about ten miles the waters are evidently much limited by high banks, so as to assume the character of little more than a narrow creek. Near the Siebengebirge a sudden expansion of the valley is evident, and from these hills, as far north as the site of Dusseldorf, there are evidences of the former existence of an irregular fresh water lake, which must have been not less than forty English miles long and from ten to twenty broad.

This basin, which I have named the basin of Cologne, is bounded on the west and east by the clay-slate and sandstone hills of Düren and Westphalia. With respect to its northerly termination near Dusseldorf, there is some little obscurity. Not far from this town there are the traces of elevated coal measures, which were originally deposited at the foot of the clay-slate hills, and which, most probably, at the commencement of the tertiary period, formed a continuous zone with similar strata near Aix-la-chapelle or Liege. Moreover, there occurs a little to the north or north east of Dusseldorf traces of the green sand or chalk formation, once, perhaps, continuous with the beds of the same description which subsist near Maestricht. Lastly, the circumstance that the tertiary deposit of the basin of Cologne has its northerly termination near Dusseldorf, along with other circumstances to which I may hereafter advert, point to the existence of an original barrier near this site, by which the lacustrine waters were confined.

In judging of the original height of the waters of this lower lake from information conveyed by the superior beds of their earthy deposit, they scarcely appear to have attained the same elevation as that of the upper basin of Neuwied.

The earlier lacustrine beds of the basin of Cologne do not differ materially from those of the lake of Neuwied, which yet remain to be more particularly described. They consist of fine sand and of plastic-clay; the only diversity being, that in some places the sand, by the siliceous agglutination of its materials, passes into a hard compact sandstone.

It is useless to prolong this general view of the earlier tertiary state of the Rheinland, by the inquiry, what might have been the destination of an overflow of waters from the lower basin of Cologne;—whether a still lower fresh water expanse occupied the present site of the low flats of Holland, extending even to the shores of England;—or into what sea the ultimate drainage of this chain of lakes was conducted. The investigation is out of the limits of the present memoir, though replete with interest of no common kind.

## CHAPTER V.

### THE ANCIENT CIRCULAR FISSURE, OR BASIN, OF THE LAACHER-SEE, OR LAKE OF LAACH.

At the commencement of the tertiary epoch, the imagination can dwell upon little more than a rugged assemblage of rocks torn in every direction by mountain torrents, which, collecting in one common channel, were furrowing out for themselves a deep bed for the descending waters.

The circumstances which at this period deranged the slate mountains of the Rheinland must not be considered as of the unmixed description which I have explained. They rather appear to have involved in them volcanic agents, which were called into action as a consequence only of the physical changes of a deeper seated nature, then in process within the interior of the globe.

The particular district of Germany which was affected by the convulsions of the tertiary epoch seems to have extended from the mountains of the Eifel to the east of Cassel, or to the west of the Harz mountains, for a distance of two hundred English miles or more; to have breadthened out from the Eifel, where it is the narrowest, and where it seldom exceeds thirty miles from north to south, to the extent of a hundred miles, which is that of its easterly limits.

One of the first volcanic eruptions which took place in the vicinity of the valley of Neuwied was apparently manifested in the basin of Laach, which differs from the vallies of disruption already described, in being of a circular, rather than of an elongated form. This shape it seems to have owed to different circumstances of origin, regarding which various opinions have been offered.

One is, that the basin of Laach was originally an *Erhebung* Crater, or crater of elevation, so named by Von Buch from the notion, (certainly a very limited one,) that it was the pressure of elastic fluids alone which elevated islands and continents above the level of the ocean;—and, accordingly, a crater of this kind is affirmed to have yielded no streams of lava, slags, rapilli or ashes, while in depth and circumference, as well as the abruptness of its walls, it is said, though very theoretically, to have exceeded the dimensions of an ordinary crater.

This view may be dismissed as untenable, on the ground that the actual ejection of trachytic felspar from the circular basin of Laach may be readily traced;—which volcanic substance is presumed to be coëval with the original formation of the basin.

It is also objected that a volcanic eruption has not in any period whatever proceeded from the crater itself of Laach, but merely from its sides. With regard to this notion, I can only state, that I am at variance with it as a question of simple observation. In order to strengthen this argument, the author of it has added, that the superior magnitude of the basin is incompatible with any other view, than that it was originally a mere mountain-lake, coëval with the clay-slate mountains themselves. This objection is equally trivial with the last. The circumference of Vesuvius at the time when the walls of Somma formed its original crater boundaries, was much more extensive; and a similar remark applies to the existing state of the extinct crater of Albano, as well as to many others in the south of Europe.—*(Uebersicht der Rheinischen und Eifeler Erloschenen Vulkane, &c. &c. von H. J. Freiberrn van der Wyck*, pages 5 to 8.)

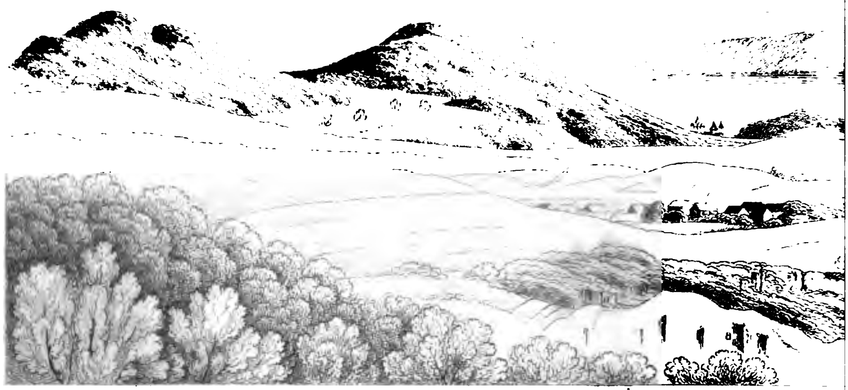
These diversities of opinion suggest an independent examination of the appearances presented by the Laacher-see in reference to better established principles.

Volcanic action has been considered by M. Elie de Beaumont as evidently connected with the high temperature now existing in the interior of the globe, and by Humboldt as one of the influences exerted by the interior of a planet during its different stages of refrigeration; yet the exact mode in which an effect of this kind is called forth has not been considered of easy explanation.

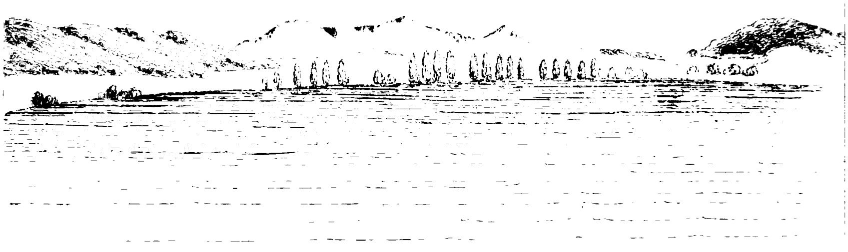
Perhaps the most satisfactory theory which can be advanced in reference to a circular basin or crater, such as that of Laach, is the suggestion of a late writer, (*See Foreign Quarterly Review for October* 1831,) that during the process of consolidation to which the interior fluid mass of the globe, from its secular refrigeration, has been subject, gases would be formed, the expansive power of which, where the exterior crust was weak or yielding, would give rise to rents or fissures.

An aperture arising from a cause of this kind would not be of an elongated form, like that which is induced during the elevation of mountains by a line often parallel to the upraised crests of them, but of a rounded or oval shape, corresponding in this respect to such a modification of fissures of disruption as M. Omalius d'Halloy has described. This geologist, in his classification of vallies, has remarked, that, if an uplifting agent, instead of acting in a manner so as to form elongated fissures, exert a propelling force upon one point only, there would result from it a species of circular fissures, which would form basins.

Thus we may easily conceive, that the first effect of elastic fluids struggling to make their escape from a volcanic focus would be the formation of an aperture from the yielding of the exterior crust, and the propulsion in a vertical direction of fragments torn from



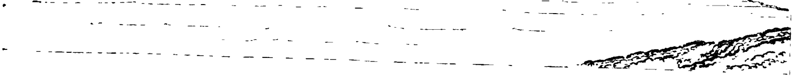
*The Laacher See From the South.*



*The Laacher See.*

*Drawn by Mr. Hibbert.*

aa Ofenstein Quarries of Bell.



the North.

Etched by E. Fenn.

its sides in a greater or less quantity, according to the incoherence or solidity of the rock through which they forced an egress.

On the presumption that the crater of Laach had this origin, a difficulty still remains, which is, to explain the disappearance of the fragments or debris forced out during the explosion.

It must be admitted that of this debris few external indications remain; and hence the supposition which may be entertained, that after the elastic gases had effected their liberation, a considerable portion, if not the whole, of the debris, had disappeared in the unfathomable profundity which had been formed. The frequent diluvial torrents also incidental to the disturbed commencement of the tertiary epoch, would contribute to sweep away and obliterate all such evidence.

At the present day the crater of Laach has a diameter which may be rated at about a mile and a half. Or, to state its dimensions more particularly, the lake of Laach is a crater-formed cavity approaching to an oval form, the longest diameter of which runs from south-west to north-east, being about a mile and three quarters in extent, while its lesser diameter is nearly a mile and a quarter. It is surrounded everywhere by abrupt rocks of clay-slate, except on its north-west and south-east boundaries.—*(See Plate II.)*

Its depth is still considerable. Notwithstanding the causes whence much of its filling up has been induced, a plumb-line still sinks to the depth of 214 feet.

In connection with this investigation, we may next inquire into *the lateral fissures connected with the central aperture of the Laacher-see.*

Von Buch has remarked, that if we suppose a succession of solid and unelastic strata to be suddenly acted upon from below by the expansive force of elastic fluids, it is evident that not merely would a central aperture be formed, but that this strain would occasion a number of lateral fissures.

That such lateral fissures can be traced in contiguity with the basin of Laach may, I think, be satisfactorily shewn, notwithstanding the modification which they must be supposed to have undergone by subsequent volcanic eruptions, or by common disintegrating and levelling agents.

That portion of the valley of the Brühl which we trace from Wassenach to the Rhine, may, I conceive, be deemed the most considerable, and the deepest longitudinal fissure resulting from the strain occasioned by the force of upheaving elastic fluids. At the same time it is not improbable, that the ground was predisposed to yield to a divellent force in this direction, from the same line of

fissure having been a previous channel for the drainage of a small lacustrine accumulation of waters into the ancient bed of the Rhine. But whether this supposition be justifiable or not, it is certain that, at the present day, the valley of the Brühl assumes the exact character, by its precipitous banks and their salient and re-entering angles, of a valley of disruption.

Some fissures which have radiated, as it were, from the central aperture of Laach, are to be detected by another species of evidence:—they have, in a subsequent period, favoured the eruption through them of basaltic lava, or, in other words, these fissures have been the predisposing condition by which columns of volcanic matter have in their ascent been enabled to reach the surface of the earth. Fissures or rents of this description may be traced west of the Laacher-see as far as the hill named the Gansehals; to the south of it as far as the millstone quarries of Niedermendig; and to the east of it as far as Eich.

One fissure, which is in the immediate vicinity of the crater of Laach, I am doubtful whether to consider as the effect of the same great strain, or not. This is the very deep one of the valley of Gleis, situated on the west and north-west of the village of that name, which may be traced from the Gansehals to the Kunksköpfe. It differs from the last described in not radiating from the central aperture of Laach, but rather in running parallel to its long diameter. The original depth of this valley is to be detected in one or two places only, having been greatly obscured by subsequent up-fillings of lava and tufa. It has a length of three miles and a-half, and a breadth varying from a quarter to three quarters of a mile.

Such is the view which I have taken after much deliberation of the earliest circumstances under which the crater of Laach has been developed.

It is doubtful, however, if the expansive power of gases is often, or indeed ever, exerted singly in producing volcanic phenomena.* In the present instance a more correct supposition is, that after the vent of the crater had been choked up by the accumulation of debris, a new generation of elastic gases had conspired with the increased pressure resulting from the still diminishing capacity of the enveloping crust of the globe, and having overcome the strong resistance of the interior fluid mass to compression, had caused a violent ejection of its substance in the form of incandescent lava.

* The affirmative is of course maintained by M. de Buch in his theory of Erhebung craters, or craters of elevation; and more recently Dr Daubeny cites in proof of it the Meerfeld in the Eifel. Unhappily, however, for the illustration of this latter gentleman, if he had extended his walk around its crater walls, he would have found that, independently of other volcanic products, the ejection of balls of olivine is a peculiar characteristic of this extinct volcano.

It must be admitted, however, that this view is only to be confirmed by circumstantial evidence. Little more than a reasonable hypothesis can be entertained regarding the earlier state of the crater of Laach, which may involve in it the following suppositions:—

*The first is, that trachytic felspar, in issuing from a deep volcanic focus, had ascended through the vent of the crater already formed.*

The support which this opinion receives has reference to appearances which in a future page will be explained in detail. In the meantime I may state, that later eruptions on the margin of the Laacher-see, consisting not of trachytic felspar but of basalt, appear to have been accompanied by a renewed disengagement of elastic fluids from the crater itself, and an abundant ejection of fragments of highly crystalline trachytic felspar, presumed to be of much older origin than the basalt, in which portions of primary rocks, such as granite, mica-slate, or clay-slate, were entangled. These inclosed fragments, in connection with other circumstances, would indicate, that at a prior period, columns of trachytic lava, in ascending through the vent of the crater in the form of veins or dikes, had displaced much of the debris with which the orifice was choked up, as well as entangled many shattered fragments within its viscid substance.

I have also, for reasons which will be hereafter explained, considered it as the most probable conjecture, that the trachyte in its earliest ascent had actually overtopped the debris through which it was protruded, and had boiled over the surface of it in the form of a lava.

A mineralogical description of this volcanic rock will more properly find a place in a future page, when I have to describe the numerous ejected fragments which are the evidence of a later extrication, through the same ancient vent, of gaseous fluids. On the present occasion it is sufficient to remark, that the variety the least changed by the renewed action of heat shows a base of felspar of a bright bluish gray colour, and of a more than common roughness or harshness to the touch, whence the Greek name of Trachyte to which it is entitled. Numerous crystals of glassy felspar, very white and translucent, are also interspersed through it, as well as divers miscellaneous products, of which a future list will be rendered.

*A second supposition is, that the earlier eruption of trachytic felspar did not rise to any considerable height, but that it remained concealed below the level of the waters of the basin.*

It must be kept in view, that the volcanic crater of the Laacher-see having been formed upon the very margin of the great lacustrine expanse of Neuwied, would be soon filled with the waters of

this lake, and be converted into a semicircular creek, hemmed in upon every side, except that of the south, by high and broken cliffs. During this state of the crater, which soon supervened to its formation, the rise of lava is supposed to have failed in attaining any considerable height, but to have long remained concealed below the level of superambient waters.

*A third supposition is, that the same eruption of trachytic felspar was accompanied by the ejection of light pulverulent matter, which, becoming diffused through the waters of the crater-lake, subsided in the form of a deep tufaceous bed, coating the upper surface of the trachyte.*

This supposition is strengthened by the solid fragments of trachytic tufa of a peculiar character, which, by much later eruptions, appear to have been detached from the depths of the crater, and to have been dispersed around its present margin.

*A fourth supposition is, that the ascent of the presumed dikes of trachytic felspar must have occurred at the very commencement of the tertiary epoch.*

This last conjecture receives support from the circumstance, that the crater of Laach, in its conversion into the form of a creek belonging to the great lake of Neuwied, was filled with a considerable deposit of sand and plastic-clay, which (as far as subsequent volcanic explosions have shewn) exhibit no marks of the heat which would ensue from a contact with incandescent lava. The inference, therefore, deducible from this circumstance is, that the presumed dikes of trachytic felspar were fully cooled and consolidated before the lacustrine deposit commenced. At the same time, when we reflect, that the trachyte in its ascent might possibly have failed in overtopping the debris which formed the low bed of the crater lake, and that under such circumstances the sand and plastic-clay would possess an immunity from the effects of infra-volcanic heat, there is as much reason for supposing that the eruption might have occurred before, as in the actual course of the tertiary deposit. The date, however, of other trachytic volcanos, as, for instance, of the Siebengebirge, rather assigns to the eruption of the Laachersee the earlier origin of the two. And it is perhaps the most probable conjecture, as I have hinted, that the trachyte in its earliest ascent, had actually surmounted the debris through which it was protruded, and had boiled over the submerged surface of it in the form of a lava.

But to render more perspicuous the views which I have inculcated regarding the earlier state of the volcanos of the Laachersee, I have endeavoured to represent it by an ideal section, where the debris which choked up the orifices of the crater is traversed by dikes of trachyte resembling in their form those of Monte Somma.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# CHAPTER VI.

## THE VOLCANIC BASIN OF RIEDEN.

But we may now turn our attention to the most considerable trachytic eruptions in the district which we are surveying.

The geographical situation of the basin of Rieden will be immediately recognized by the geologist when I state, that it is situated about two or three miles to the west of the lake of Laach.

The limits of the valley of Rieden, which are so irregular as nearly to baffle description, exhibit on all sides bold declivities, or in the place of them, abrupt and insurmountable precipices. Nor are the inequalities of surface which characterize its recesses less striking. These, when contemplated from an eminence such as that of the commanding point named the Gansehals, exhibit such a multitude of insulated cones, of towering peaks, or of deep and narrow ravines, the whole clothed with almost impassable thickets, that the mind appears perfectly lost, and it seems at first view the most hopeless of tasks to thread with any degree of geological accuracy this perplexing and almost inextricable maze.

This is the sole reason that the district which I would now describe appears nearly a blank in all the dissertations which have yet been published of the volcanos of the Rhine. "In no other part of these confines," says one of the latest geological visitors of the Rheinland, "have the deluging effects of waters and currents in connection with volcanic eruptions, with subsidences and trachytic elevations, occasioned a greater confusion than in the neighbourhood of Rieden, Weibern, and Kempenich. We can observe only the trachytic Burgberg, the half defaced crater-shaped cavity, the destroyed and displaced basaltic lavas, the great fragments of leucitic trachyte which lie scattered upon an ovenstone, (indurated tufa) disposed in strata, or which are inclosed in it,—and the deposit of the most recent sandstone formations which alternate with volcanic ones. Every thing here appears chaotic and intermingled.

Without new topographical observations, connected with elevations, it is not possible to give a distinct representation of this district."—*Uebersicht, &c. &c. von H. J. Freiberrn van der Wyck.*

In despairing sentiments like these I was myself at first disposed to indulge. But after some little observation, the great difficulties to be encountered reduced themselves to the following: The first, which was by no means a small one, arose from the dense state of the forests and thickets. This I readily obviated by returning to the site early in the spring, before the foliage had appeared; while the second, which was the complex geography of the place, I subdued by a regular survey of the ground. *—*(See Plate III.)*

After these observations, I shall now attempt the very difficult geology of the basin of Rieden.

The history of the basin of Rieden may be summed up in a few words.—It has been a volcanic crater, apparently induced during the incipient liberation of elastic gases:—Secondly, it has been the seat of trachytic eruptions:—Thirdly, it has been filled with a tufaceous mud:—Fourthly, this tufaceous mud has overflowed into adjacent vallies or lakes: And, fifthly, this basin has been the seat of later eruptions, consisting of basalt.

These circumstances being premised, we shall consider each volcanic incident in the order of time which it appears to have observed.

### Section I.—The origin of the Basin, or Crater, of Rieden.

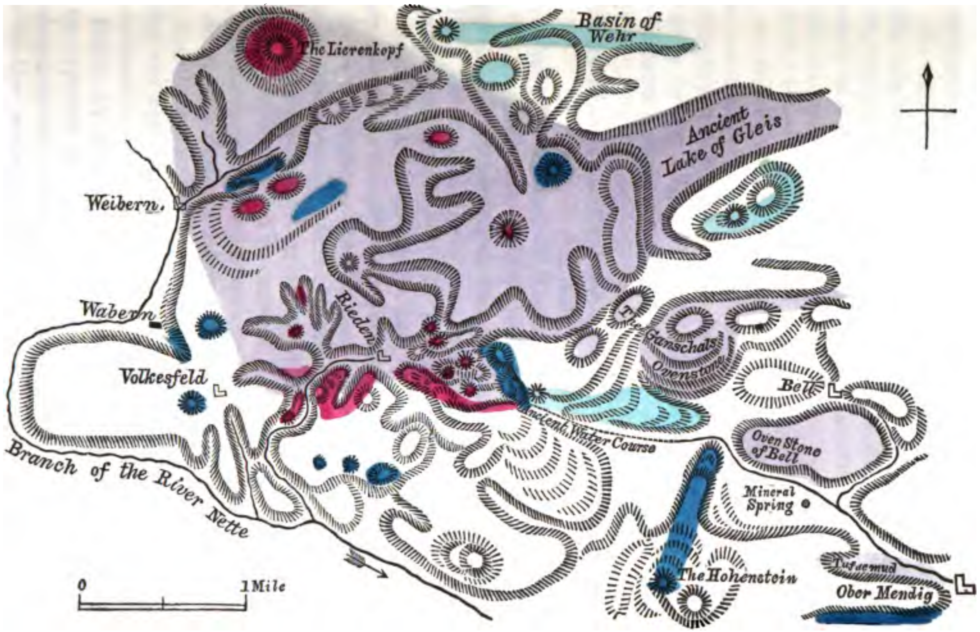
It has been stated, (page 14,) that it was of importance to keep in view, that the most numerous set of vallies connected with the basin of the Neuwied was parallel to the channel of the Rhine, which I have considered as a valley of disruption; that by these parallel vallies, which run from S. E. to N. W, the whole of the district which we are examining had been intersected; and that, with few exceptions, subsequent volcanic eruptions had conformed to this parallel line of fissures.

A remark was likewise made, (page 13,) that the valley which from its greatest length appeared to be of the most determinate character, was that which we trace in this common direction of S. E. to N. W. from the heights of Leimbach and Kempenich, for a distance of twelve miles, to the south of the town of Mayen on the river Nette. Along three-fourths of this line, namely, from the Ovenstone quarries of Bell to Hahnenbach, there is an almost un-

* Or rather, I ought to state, that I am indebted to Mrs Hibbert for the labour of transferring with accuracy the observations which I had made of this vicinity to the map constructed by her which accompanies the present Memoir.

*III.* 

**Geological Map of the Basin of Rieden.**




Trachytic eruptions are coloured red.
Basaltic —— blue.
The tufa is —— purple.
Rocks of clay-slate are uncoloured.

*Drawn by Mrs Hibbert.*

*Cut in Wood by F. G. Bruce.*

interrupted series of trachytic eruptions. Of these the most considerable is to be found in the south of the line, namely, in a valley, which, from the village situated in it, I have named the valley of Rieden.

It was probably soon after the process of elevation to which the line of hills extending from Mayen to Hahnenbach became subjected, that the basin of Rieden dates its origin. It forms one of the many circular fissures occurring in this volcanic district, which was induced by gaseous fluids given out during the secular consolidation which the interior fluid mass of the globe has undergone; and which, in exerting a powerful uplifting force for their extrication, has formed in many places deep and yawning rents. In consequence, however, of a long series of volcanic eruptions, the original shape of the cavity has been much distorted. It is notwithstanding capable of being traced, and appears to have been nearly of a circular form, having a diameter of about a mile and three quarters to two miles.

After the elastic gases had effected their liberation, the fragments, or debris, torn from the fissured mountain during this process, must have either wholly disappeared in the unfathomable profundity which had been formed, or must in part have been swept away by the diluvial agents which were in activity at the commencement of the tertiary epoch.

## Section II.—The Trachytic Rocks of the Basin of Rieden.

The vent of the crater of Rieden had not long been choked up by the accumulation of debris, when columns of incandescent lava appear to have ascended, and in their course to have entangled within their viscid substance many shattered fragments resulting from the perforation which had been induced.

The miscellaneous products which appear to have risen from the deep aperture of this volcanic basin form the rocks which geologists name *trachytic*,—that is, they have a base of felspar, and include in various proportions crystals of glassy felspar: they are also in different places more or less modified by the presence of hornblende, augite or leucite. The outward limits, however, of this great fissure, are distinguished by eruptions of basalt, but as these are of a later date, they demand a subsequent and distinct consideration.

The conditions under which these trachytic rocks have been protruded are well displayed in their present striking appearance and distribution. Subsequently to the immense disengagement of elastic fluids, by which the crater of Rieden was first formed, it might be expected that any future generation of vapour would become comparatively trifling, the effect of which would be chiefly evident in the pressure which it would be enabled to exert upon the interior fluid mass of the globe, whereby portions of its viscid

substance in the form of columns of lava would be detached and forced upwards through the vent of the crater already formed. The ascent of the felspathose lava would be also promoted by its superior degree of liquidity, by its lower specific gravity, and by the comparatively little resistance which it would meet with from the loose debris with which the orifice of the crater of Rieden must have been very early gorged.

In the present instance, the elastic fluids originating in the volcanic focus appear to have been generated in sufficient quantity to propel to a considerable height above the bottom of the crater immense columns of lava, and, as a general result of the process, to promote the elevation within the actual limits of the basin of various trachytic cones.

The mode in which these trachytic cones have been formed it is not very difficult to trace. When a column of lava is propelled to a greater or less height above the orifice whence it has issued, a small vent at the summit of the elevated mass is generally formed, over the lips of which the lava has been known to boil or extravasate, like some thick or viscous liquid over the edges of a circular vessel. During this process the lava has spread on all sides in undulating streams, so as to gradually put on the configuration of a cone increasing in elevation and diameter according to the continuity of action exerted by the elastic fluids in their escape through the aperture which they had formed, and according to the distances whence undulating streams of lava have diverged from the central aperture of their extravasation.

Lastly, upon the suppression of the volcanic energy, the small perforation permitting the escape of elastic fluids would be promptly obliterated by the filling in of the viscous fluid, agreeably to the common laws which regulate the motions of fluids.*

But to add further elucidation to the views which I have sought to inculcate, I have subjoined the following section, which is of course partly hypothetical:—

*Crater of Rieden.*

*Trachytic cones actually displayed in a section from N.W. to S.E.*

*Ideal section of Trachytic lava protruded through the loose debris with which the vent of the crater was previously choked up.*

* Much information on the mode in which volcanic cones are formed may be derived from M. Bory de Vincent's description of the volcano of the Isle of Bourbon, as well as from Mr Scrope's luminous comments upon it.—(*Considerations on Volcanos*, p. 54, &c.)

Such is the process by which the columns of trachytic felspar which were protruded above the deep confined abyss of the basin of Rieden formed isolated or even connected cones. Their ascent may be often observed to have taken place near the bounding walls of the basin, where they have either risen in the form of high and surmounting peaks, or in viscid streams have sought the low and confined depths of the valley, which they have filled with thick and sluggish accumulations of lava. A state of quiescence has been thus induced, favourable to the condition considered by Von Buch as indispensable to the formation of leucitic ingredients.

From these circumstances we are led to infer the general appearance which would be presented upon the first breaking out of these trachytic rocks. If our imagination is capable of transporting us to a period apparently antecedent to the habitation of Europe by the human race, we should find, that, upon attaining the summit of the high plateau of clay-slate, within the interior of which the present wooded valley of Rieden now appears, we should perceive ourselves upon the brink of a hideous precipice, looking down upon a burning lake some hundred feet below us, contained within a vast fissure, while several conical islands formed of the same incandescent matter, would be elevated above the fiery flood. The appearance would, in fact, find something like a recent analogy in the volcanic phenomena of Owhyee, lately described by Mr Ellis the missionary. This author states, that, upon approaching the volcano of Kirauea, he expected to have seen a mountain with a broad base and rough indented sides, composed of loose slags or hardened streams of lava, and whose summit would have presented a rugged wall of scoriæ, forming the rim of a mighty cauldron. But instead of this, he adds, he found himself on the edge of a steep precipice with a vast plain before him, fifteen or sixteen miles in circumference, and sunk from two to four hundred feet below its original level. The same traveller then continues to describe the surprise which he felt, while descending amidst these vast lava-fields, to find in that portion of it where the volcanic energy was still active, an immense gulf, (to use the author's own expression,) where was a vast flood of burning matter in a state of terrific ebullition, with numerous conical islands rising round the edge or from the surface of the burning lake.

But it is now important to add, that, if this description be at all relevant, it can only apply to this ancient volcano of the Rheinland in its incipient stage, for the exemplification of which ample details are afforded in the numerous varieties of trachytic rocks to be met with, particularly on the south or south-easterly side of the valley of Rieden. These are as follows:

1. A volcanic rock, having a base of felspar of a greenish grey colour, and of a compact texture, which has evidently suffered more by the action of heat than most of the other varieties to be found in this locality. For, among the numerous small crystals of felspar which the base contains, some are in a vitreous state; others are either reduced to the state of a kaolin, or to that of a whitish powder, while the rest have been so affected by the intensity of volcanic fires that the substance of them has nearly disappeared, small corresponding pores being left as memorials of their prior existence. This rock likewise contains many small fragments of clay-slate entangled by it during its propulsion.

2. A second rock which is to be found on the south-east of the valley has a base of felspar varying from a fawn colour, which is the most prevalent, to one of a yellowish and hair brown of a darker shade. The texture is compact. Minute crystals of glassy felspar and hornblende are sparingly disseminated through it.

3. The base of another rock is of nearly a similar colour to the last, the shade being perhaps darker. But its texture is granular rather than compact; or, to explain this character, when viewed through a microscope, it exhibits countless granular particles of a darker coloured felspar disseminated in a base of a lighter colour, and intimately blended with it. The structure of this rock is also inclined to the schistose. Crystals of glassy felspar, some of which pass into the state of a dull white kaolin, and those of hornblende are even fewer than in the last variety.

4. The felspathose base of a fourth variety is of a darkish hair brown colour, with a compact texture and a schistose structure. It contains a few crystals of glassy felspar, but chiefly differs from the preceding varieties in the greater diffusion through it of crystalline particles of hornblende.

5. A fifth variety has its texture characterized by a commixture of minutely granular particles of an olive green colour, but differing in their degrees of shade. Crystals of hornblende and glassy felspar are sparingly observable in it.

6. A sixth variety, which is a very abundant rock in this valley, has a bright greenish grey base of felspar with a compact texture and a very uneven fracture. I have been able to detect in it but few crystals of glassy felspar, and no augite or hornblende. It is chiefly remarkable for the innumerable particles of leucite, about the size of millet seed, which are imbedded in it, but which are so intermingled and confounded with the felspathose substance of the base, that they have scarcely preserved more of their forms than pale coloured outlines, most of these even being very imperfect. It is, however, possible to detect a few perfect crystals of leucite, amounting in size to that of peas. This rock is extremely decomposable.

7. A seventh variety has a base of felspar of a dark yellowish gray colour, with a very compact texture, and a structure slightly conchoidal. Like the last described rock, it contains numerous small and indistinct particles of leucite, but along with them minute yet perfect crystals of glassy felspar and of augite or hornblende,—it is difficult to say which. This rock, from the effects of heat and sudden cooling, may be observed in a few places to pass into a dark-coloured pitchstone, varied by minute white spots, the indications of included particles of leucite.

8. An eighth variety has a base of felspar of various colours and shades. The colour of one is clove brown, mixed with ash grey and a small tinge of red, forming altogether what Syme in his Wernerian nomenclature names a broccoli brown. In other instances the felspar is of a bluish or blackish gray rather than of a broccoli brown tint. The texture of the rock is minutely granular. It is also densely studded with crystals of leucite, varying from the size of millet seed to that of small peas, and these exhibit various tints from a wine yellow to that of a hair brown. Small crystals having rather the character of augite than of hornblende are almost as abundant as the leucite, and along with them are crystals of glassy felspar, some few of which are of the dimensions of half an inch or more. In the bluish or blackish grey specimens I found these last mentioned ingredients more proportionally interspersed. Lastly, this volcanic product contains in it fragments of the primary rocks through which it has been protruded, as for instance granite very materially altered by heat, large scales of black mica, &c.

9. A ninth variety has a felspathose base of a bluish grey colour, chiefly remarkable for its crystals of white leucite, which occur in an abundance that is perfectly remarkable, forming in some parts of the rock a great portion of its substance. Next in quantity to the leucite is the augite, which enters intimately into the substance of the base. I could not detect in this variety any glassy felspar.

10. A tenth variety, which is not an abundant rock, has a lavender purple base of felspar. In its texture it is granular, and also contains numerous small pores. Crystals both of hornblende and augite, chiefly the former, enter into it, which are much larger than those of any other rock of the valley, some of them being of the dimensions of the fourth of an inch. It also contains, though very scantily, crystals of leucite.

11. An eleventh variety has a blackish green base of felspar, in which numerous crystals of hornblende are disseminated, to which it probably owes its particular colour. In its texture it is minutely granular. Glassy felspar is with difficulty to be detected in it. Crystals of leucite varying from the size of a common

millet-seed to two or three times that magnitude are interspersed through it, though very scantily; these being far less decomposable than the base in which they are contained, may be observed in weathered specimens to fall from it in distinct crystals.

12. A twelfth variety has a felspathose base of a greenish black tint, which it doubtless owes to the colouring matter of hornblende, but it differs from every other rock of this valley yet mentioned in its compactness and hardness, which is equal to that of a basalt or greenstone. When examined through the microscope many very minute spots of a whitish substance may be found interspersed through it, which I have been in doubt whether to consider as molecules of leucite, felspar, or even quartz;—perhaps they are of the first named ingredient.

13. The remaining variety to be described is one that resembles the last in the numberless minute spots which are to be detected in it by the microscope, and which, on decomposition, certainly appear to most resemble leucite. But it has a different colour, namely, that of a reddish or liver-brown, and it is of an inferior compactness and hardness. It also contains small crystalline particles of hornblende or of augite, and minute scales of mica.

From the list now given of the more ancient volcanic rocks of the valley of Rieden, it will be seen that they have all a base of felspar more or less diversified by the presence of glassy felspar, hornblende or augite, and that many varieties have to boast of the diffusion in a remarkable quantity of crystals of leucite. By some writers other minerals have been recorded as occurring among these rocks; as, for instance, Nosin and Hauyne.

It may be also added, that many of these varieties pass into each other by almost imperceptible gradations.

The structure of the trachyte is nowhere remarkable. I have not seen it prismatic. It is in general divided by seams into polyedrous or rhomboidal fragments.

M. Steininger has noticed volcanic balls strewed about the vicinity of this basin between the Gansehals and the Selberg, which he supposes to have been erupted, along with ashes, from the first mentioned place. These balls he describes as having a sort of *wacke* appearance, and as containing glassy felspar, leucite, mica, and hornblende, and even melanite and spinelle.

Fragments of various kinds of trachytic rocks are also found near the Gansehals, and, according to some writers, fragments of opaline felspar. They appear scattered upon the ground.

The nature, likewise, of the primary rocks through which volcanic streams have been protruded, is here displayed. Ejected fragments of granite are observable, one of which, collected by me, has a whitish or yellowish coloured base, containing large crys-

tals of felspar, which have been reduced by heat to a vitreous state, and small specks of hornblende. The mica is in minute quantity.

Such are the varied products of Rieden, which are mostly found in a lithoid state. The slaggy form is indeed a comparatively rare occurrence.*

## Section III.—The Tufaceous deposit accumulated within the Basin of Rieden.

It may be here stated, that in the attempt to investigate, in an order of time or succession, the appearances presented by the valley of Rieden, an early priority of description has been allotted to rocks of trachyte, which ought, however, to be accompanied with this explanation, that we are not warranted in concluding that they were protruded from the volcanic focus exactly at one time; the greater probability being, that the various volcanic cones or congealed flows of lava displayed within the basin were the result of a series of eruptions, some few of which were continued during the formation of the tufa.

Either contemporary with the fiery floods which were thus confined within an abyss of the mountains, or subsequently to the period when they had begun to roll, torrents of water from each commanding eminence would descend into the basin, and would give rise to new and tremendous phenomena. These are indicated by the beds of tufa of an immense thickness, which in every part of the cavity are superimposed upon trachytic rocks, presenting indications of the early site of a volcano of mud, or *moya*, similar in its character to those appalling ones of the western world, the ravages of which have been commemorated by Humboldt.

It is well known, that, besides the protrusion of lava in a flowing and viscid state, light pumiceous matter forms a considerable portion of volcanic products. In most of the extinct volcanos of this character which I have studied, the nature of their tufa-

* In this description of the felspathose rocks of Rieden, it was my wish to have appended to them the names which have been recommended by some distinguished geologists. But, whether from my own unskilfulness, or from some imperfection in the classifications themselves, or perhaps from both causes together, I have certainly found the task beyond my ability. I shall therefore content myself with remarking, that the varieties here detailed may, I conceive, be referable to the trachytes of Brongniart, with the exception of perhaps a few of them, which may have bases approaching to the Diorites, Eurites, Ophites, or Argilolites of systematic writers. At any rate, I have attempted to define each variety of rock with such accuracy, that those who are strenuous for more particular systematic names can scarcely fail to find sufficient data for their purpose.

ceous deposits has convinced me, that pulverulent particles of trachyte, generally of a milk or yellowish white colour, and intermingled with minute portions of pumice, are so frequent an accompaniment of trachytic eruptions, as to almost merit being considered as one of their characteristics. From their very minute state of mechanical division, and extraordinary fineness, they readily, when mingled with water, form a paste.

Under ordinary circumstances, these extremely levigated particles, as they issue from the volcanic focus, would be dispersed by volumes of gas and vapour, and be carried into the more elevated regions of the atmosphere, there to become the sport of winds; a very light current of air being sufficient to transport them to a considerable distance.

These conditions being premised, we may readily conceive of the focus of a volcano, in which such minute and light trachytic particles are elaborated, being called into activity beneath a cavity half filled with incandescent lava, into which would soon flow various mountain streams. In this case it is evident, that the superambient waters of the lake would intercept all the light particles of volcanic matter which would otherwise have been projected high in the air, and widely dispersed over a large surface of territory, causing them to be mingled with water of a temperature highly elevated from its contact with incandescent lava. The mixture would then assume the consistence and character of a boiling mud.

There are again other circumstances, though subordinate ones, to be considered, which, while they have promoted the accumulation of tufa, might have possibly conspired in modifying its mineralogical character.

The first of these is the decomposing effect resulting from the increased temperature of the water.

In examining the character of the tufa of Rieden, it is evident that the strong chemical energy which water raised to a high degree of temperature would exert upon earthy substances, must be the most evident in sites where the boiling mud would come in contact with protruded trachytic rocks while in a state of ignition. Now this is remarkably exhibited in the instances where this proximity can be traced. The lowest strata of the valley of Rieden show, that the mud which was deposited upon the surface of incandescent lava has its ingredients often reduced to an extreme state of fineness, indicative of the complete disintegration, and often decomposition, to which any coarse ingredients must have become subject. That this effect is due to a chemical energy increasing with the temperature of the water, is evident from the reflection, that if volcanic ingredients of different de-

grees of fineness or coarseness had been diffused through a cold watery medium, they would have subsided according to the laws of gravity ; the coarser ingredients occupying the lower situation.

There is likewise some reason for supposing, that the same agency of heat has had a general influence in adding to the muddy contents of the basin. Thus, in the instance of a hard leucitic greenstone, which, under ordinary circumstances, was little decomposable, the surface of the rock appears to have passed by almost insensible gradations into the substance of its tufaceous coating.

A second circumstance to be taken into consideration, is the decomposing effect which would arise from the water absorbing many substances, familiar to the naturalist, which issue from the volcanic focus. Chlorine, for instance, hydrogen gas, carbonic acid gas, along with sulphureous vapours in different forms, are well known products of many volcanos, which, either singly or in combination with alkaline or metallic bases likewise generated, would no doubt be in part absorbed by the lacustrine waters through which they were propelled. Thus, the waters which issued from the cavernous recesses of Etna during the convulsion of the year 1751, were not only in a state of ebullition, but had even acquired saline qualities. Such chemical properties, in fact, does the lake of Laach retain, though very slightly, even at the present day ; the labours of the chemist having detected in its waters the presence of the carbonate of soda. Let us then suppose, (what is even more than probable,) that the lacustrine waters of Rieden, besides being intermingled with earthy particles in a state of suspension, were freely impregnated with mineral or saline compounds elaborated during volcanic operations, and there would be doubtless imparted to them a considerable decomposing power, which, in acting upon solid rocks of trachyte, or even upon the larger cinereous or pumiceous fragments which were ejected, would not only promote the accumulation of the tufaceous mud, but likewise endow it with new mineralogical properties.

This mud or *moya* (if I may be allowed to use the Transatlantic synonym,) during the progress of its cooling appears to have subsided in the form of a stratified deposit. Sufficient evidence is afforded of this result in the tufaceous coating which still in part conceals most of the trachytic eminences, and which lines the very brim of the containing basin.

To illustrate this fact more distinctly, I have endeavoured in the annexed slight section, (from N. W. to S. E.,) to convey a notion of the basin of Rieden, as it must have subsisted in a state of integrity subsequent to the cooling of the contained moya.

*Tufaceous Strata.*

*Trachytic Eruptions.*

But it is necessary to remark, that the walls of the basin, where the filling of it with moya first took place, had a height rather lower than that which they afterwards assumed, particularly on the south, where a drainage of it had commenced. For this reason, the tufaceous strata which are entitled to a priority of description must be sought for amidst such as were deposited antecedent to eruptions of basalt, to which in many places the augmented elevation of the walls is due.

These are the very general observations with which I shall content myself on the origin of the tufaceous strata of Rieden, preparatory to a description of them in their present indurated state.

They are usually of a yellowish or light-brown colour, and are finer or coarser in proportion to the degree with which their ingredients have been enabled to resist decomposition. Thus, we find enveloped in a tufaceous paste composed of minute particles, small portions of trachytic felspar, or of pumice, as well as crystals of glassy felspar, of leucite, or of hornblende, and, in some places, heterogeneous fragments, generally of diminutive magnitude, of the rocks, chiefly clay-slate, through which lava had been protruded. In other instances, however, the various ingredients of the tufa seem to have undergone a perfect decomposition, and an apparently homogeneous mass of a slaty structure is the result. It may be also observed that these strata exhibit very different degrees of hardness, some being soft, while others are of nearly the consistence of freestone, for the purposes of which they are in daily use.

Some few peculiarities of the tufa may now be noticed.

About half a league south by west of the village of Rieden, on the right of the stream as we trace it towards the present gorge of the valley, a deposit of very fine tufa may be observed resting upon clay-slate;—this being in fact the only site where the common primary rock of the district is found within the basin. The tufa is of a yellowish-grey colour, consisting of the finest possible particles, which are pulverulent to the feel, which, when rubbed on woollen, leave a mark upon the cloth, and which are easily

scraped by a knife. In other respects, however, the tufa is cohering and solid. When broken, it is remarkable for showing in various places systems of concentric rings of a chesnut-brown colour, like those of some arborescent product, which differ in their diameter, the smallest being that of a pea, while the largest is two inches in extent. The rings of each system vary from two to five or perhaps more in number, while, in some of them, there is a sort of nucleus in the centre about the magnitude of a common pea. Whether these appearances can be rationally referred to a vegetable origin, I am yet unable to say.

Contained in this tufa are masses, some feet in extent, of a substance rather different in its external appearance. It is of a pale wine-yellow colour, variegated with almost equally pale yellowish-grey shades. It is, like the tufa which encloses it, very light; its specific gravity being about 1.79. Its great difference, however, consists in its firm and compact texture, and in its clear conchoidal fracture, owing to which peculiarity of structure, as well as its containing systems of concentric rings, it acquires a faint resemblance to ligneous matter. At the same time, this suspicion is little strengthened by the nature of its chemical ingredients, which consist of silica, alumina, magnesia, and lime. The last substance might have possibly been derived from calcareous springs issuing through tufaceous matter.

Associated with these substances is a tufa, in which may be traced minute particles of white decomposed felspar, along with others of a deeper shade, of a wax-yellow tint.

In other parts of the valley of Rieden we find a very compact and fine tufa of a bright yellowish colour, which is very fissile, and breaks into laminæ of about an inch to an inch and a-half in thickness. It is in some places diversified by layers which contain small fragments of rocks, wherein the substance of clay-slate is perfectly distinguishable.

Elsewhere the tufa is of a coarser texture. It is characterized by particles of a yellowish and light brown colour mixed with minute scales of mica, comminuted particles of hornblende, &c. Upon exposure to a dry atmosphere, it acquires considerable hardness and consistence. It is also disposed into thick tabular masses, often regularly stratified, into which it splits.

A tufa of this character readily recommends itself for economical purposes, and is, therefore, in the valley of Rieden extensively quarried, being named by the natives, from its valuable quality of resisting the effects of heat, *Ovenstone*. When raised from the quarry it is in comparatively a soft state, which is availed of

by the workmen for reducing it on the spot to the shape required.

There is again a still coarser tufa which has resulted in part from decomposed trachytic rocks. It is often of a yellowish brown colour, containing in it abundant crystals of leucite, of a very perfect form. This circumstance may arise from the superior power of leucite to resist decomposition, whence its superiority of abundance over crystals of glassy felspar.

These are the principal tufas indicative of the boiling tufaceous mud, or moya, which once filled, even to an overflow, the valley of Rieden. Some other varieties might be described, which generally form the higher strata; but as the latter were apparently produced during a later period, they will be described in an ensuing section.

## Section IV.—The overflows of Tufaceous Mud, or Moya, from the Volcanic Cauldron of Rieden.

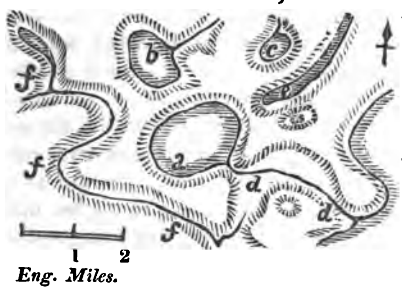
In the last section the circumstances were investigated under which an accumulation of tufaceous mud, or moya, has been formed. This substance, while in a state of ebullition, must have imparted to its containing cavity the character of a cauldron rather than of a common basin.

After this inquiry we may consider the various overflows of boiling mud which were discharged from the interior of this volcanic cauldron.

But, as a previous and indispensable measure necessary for our understanding the various circumstances under which these different overflows have taken place, it will be important to obtain some general notion of the situation of the basin of Rieden, in reference, first, to an ancient tertiary lake which I have named from the town now existing in the centre of the drained site, The Basin of Neuwied; and, secondly, to certain minor vallies, or contemporaneous craters.

To impart to this object sufficient intelligibility, an accompanying plan is attempted of the state of this district at the commencement of the tertiary epoch. It must not, however, be supposed that such a sketch is an hypothetical one. I would rather have it considered, even in the simple form which it now assumes, as one of the ultimate deductions of a very laborious and tedious investigation.

SKETCH ILLUSTRATIVE OF THE TERTIARY GEOGRAPHY OF THE BASIN OF RIEDEN, &c.




*a* Basin of Rieden. *b* Basin of Fusel. *c* Basin of Wehr.
*d* The ancient water-course by which an overflow from the basin of Rieden was conveyed into the lacustrine expanse of Neuwied.
*e* The ancient lake of Gleis. *fff* A branch of the river Nette from Kempenich.

In allusion to this sketch it will be observable, that the basin of Rieden (*a*) was situated on the margin of the tertiary lake of Neuwied. The bed of this large lake, as I have previously explained, occupied all the low land which we trace along the course of the Rhine from Coblentz to Andernach. Its extent was 16 to 18 miles from east to west, and 4 to 7 from north to south.

On the north a narrow clay-slate ridge divided the basin of Rieden from that of Wehr, *(c)* also of volcanic origin; and west of the latter, the same clay-slate ridge, subsequently widened by the interposition of an invading volcanic rock named the Lierenkopf, separated it from the basin of Fusel; (*b*).

On the east a clay-slate ridge divided the valley of Rieden from the crater lake of the Laacher-see and the basin of Neuwied, the waters of which were then intermingled; and, by a similar interposition on the west, the valley of the Nette *(f f f)* was separated.

But the southerly boundary acquires the most interest. It must be carefully kept in view that the height of the cliffs which formed these limits was originally lower than is exhibited at the present day; their elevation having been subsequently increased by overtopping eruptions of basalt. Accordingly, when the walls of the basin of Rieden were comparatively inconsiderable, an eruption of its waters was carried off by a ravine, (*d d*) which conducted them in a south-easterly direction to the basin of Neuwied.—*(This is represented in the wood-cut.)*

After this elucidation, we are prepared for inquiring into the co-operating causes which might have induced the overflows of tufaceous mud which have their origin in the basin of Rieden.

One of the causes giving rise to the overflow of tufaceous mud

may be referred to periodical or occasional floods of water swelling the volume of the muddy contents of the basin.

That the basin of Rieden, whether in the state of a common crater lake, or of a volcanic cauldron filled with moya, was liable to overflowings from periodical or occasional floods of waters swelling the volume of its muddy contents, is to be inferred from the deep water-course which may be traced on the south-east of the basin. In examining a portion of this ravine, which near Bell is excavated through rocks of clay-slate, we find at the bottom of it two deposits, the lower of clay, and the higher one of loam, which had apparently their origin before any eruption of volcanic mud had commenced; while above them is a thick accumulation of volcanic tufa (yet to be described) with which the water-course was subsequently choked up.

But this original drain would only be efficient when the walls of the basin from which the outlet was conducted were comparatively lower than at present. For, in a later period, a change occurred. The source of this drain was obliterated by the intervention of protruding volcanic rocks, which in breaking through the very brim of the crater appear to have added considerably to its height; compelling at the same time the waters of an overflow to excavate for themselves some new channel of escape.

To render this description of the original or *prior* state of the basin more intelligible, the sketch of it may be again consulted, where the drain in question will be found indicated by the letters *d, d.*

Having described the appearance indicative of one of the causes to which many overflows of moya into contiguous vallies may be referred, I shall now advert to another co-operating agent.

Although a considerable share of the tufaceous mud thus deposited may be supposed to have owed its origin to accessions of water swelling the volume of the muddy contents of the basin, and thus causing an overflow, yet it is certain that another cause must have still more conspired in producing the same effect, namely, renewed eruptions of lava within the actual confines of the basin. In this latter case it is evident, that a considerable volume of tufaceous mud would be displaced, and that, in its farther elevation by the expanding force of the elastic gases which would be liberated, it would boil over the sides of the cauldron, and be precipitated into contiguous vallies.

To such a cause I would certainly refer some share of the overflow which has been described, consistently with the observation which I have made, that we are not warranted in concluding that the trachytes of Rieden were protruded from the volcanic focus exactly at one time; the greater probability being, that the

various trachytic cones or congealed flows of lava displayed within the basin were the result of a prolonged series of eruptions.

With these few general observations I shall now content myself, and, in proceeding to describe the overflows of moya incidental to the cauldron of Rieden, such as have found a lodgement in deep and dry vallies or ravines will be distinguished from others which have been ultimately conducted into contiguous lakes.

1*st*, *The overflow of tufaceous mud, or moya, which was conducted by the ancient water course on the south east of the basin of Rieden into the lacustrine expanse of Neuwied.*

There is every probability that, owing to various periodical or occasional accessions of water imparted by mountain torrents to the basin of Rieden, it would be subject to a gradual process of overflow, accelerated only by the sudden discharge of moya which would ensue when protrusions of lava intervened.

During this process, much volcanic mud would flow over the south-easterly walls of the basin, which at this point appear to have rapidly declined towards the great lake of Neuwied; and having been transported along the line of the ancient ravine, which I have described, would be extensively diffused among lacustrine waters.

From this intermixture a very modified deposit would be the result. The substance of the tufaceous mud would be so intimately blended with the fine sand and plastic-clay, which are the characteristics of this tertiary lake, as to assume a less firm consistence, which at the present day is indicated by the rapidity with which the mixed deposit is disintegrated, particularly by the action of rains. But although the tufa is thus disguised, its origin, after a little experience, may be easily recognized, owing to the yellow or brownish colour, and pulverulent, yet harsh feel, which it continues to preserve.

There is also abundant evidence to show, that the moya which was thus washed into the lake became acted upon by currents, particularly from the west and north-west, and that, having been distributed over a surface of several miles in extent, it has served to fill up considerable depressions, where it has been deposited in the form of regular strata. It may likewise be observed, that the lighter particles have undergone the most distant transportation, whence the greater fineness of the product in proportion as we recede from the source of the mud eruption.

The sites which are at present filled with the remains of this mixed deposit, may be found upon the south-west and south of the margin of the Laacher-see, where various small hills or knolls attest its presence. Indeed, there is reason to suppose, that some of it

was carried into the lake of Laach itself, (which then mingled its waters with those of the Lake of Neuwied,) though at an advanced period of the plastic-clay deposit, which on the north of this crater appears pure, and unmixed with tufa.

The greatest share of this tufa, however, was not transported easterly towards the Laacher-see, but rather in a south-easterly direction towards the present site of Obermendig and Thur, a distance of three or four English miles, where the deposit lies very deep, particularly in the vicinity of the last named place.

*2dly, The overflow of tufaceous mud which was lodged in the ravines of the Gansehals and of Bell.*

During one of the later eruptions of Rieden, which is perhaps indicated by some trachytic eminences observable on the south-east of the basin, a large overflow of tufaceous mud took place, no doubt in a state of ebullition, the progress of which we shall next endeavour to trace.

In the course of this convulsion, the volume of tufaceous mud, which, in a cavity already filled to the brim, had been displaced by some new protrusion of trachytic lava, would find a ready escape through the breach in its walls, which had been effected by the corrosion of the water-course to which I have before alluded.

But so immense was the volume of the displaced mass, that, after rapidly descending in the course of the furrow which mountain torrents had wrought, it at length became, in proportion as the steepness of the declivity lessened, gradually moulded, as it were, into the trough-shaped ravine which was its recipient, and before it could reach the waters of the Lake of Neuwied, had its course finally impeded by high projecting slate-rocks. Here it found a quiescent lodgement.

The tufa in hardening now appears as two shapeless unstratified mountain heaps, although there is little doubt but that originally these were continuous; the separation having been gradually effected by corroding streams. The substance of it is named by the Rheinlanders *Ovenstone*, indicative of its power of resisting heat, and of the economical purpose to which it is applied.

The more northerly mass of ovenstone derives its name from a commanding eminence, the foot of which it lines, being usually styled THE OVENSTONE OF THE GANSEHALS. Its situation is sufficiently well illustrated by the drawing which accompanies this description, (See Plate IV.) where it appears exactly below the brim of the basin of Rieden, indicating, without the aid of further description, the volcanic crater whence it has been derived.

PLATE IV

The more southerly mass is distinguished as THE OVENSTONE OF BELL, from its vicinity to the village of that name. In one of the sketches which has been attempted of the Lake of Laach, (See Plate II. page 23,) the view is stated to have been taken from the small eminence formed by the Ovenstone of Bell. But the drawing conveys little or no information of the relative situation of this erupted mass, which is better learned by the section given in the following page.

The conjoined length, from north-west to south-east, of these two masses of Ovenstone may be rated at about a mile and a-half, while their breadth, which is very irregular, does not perhaps exceed a third of this extent. The thickness of the ovenstone varies much owing to the inequality of the ground upon which it has been deposited. It is the greatest at the Gansehals. Near Bell, where it is the least, it has been estimated at fifty to seventy feet; but I am doubtful if this measurement is not rather confined to the depth of the workable mass.

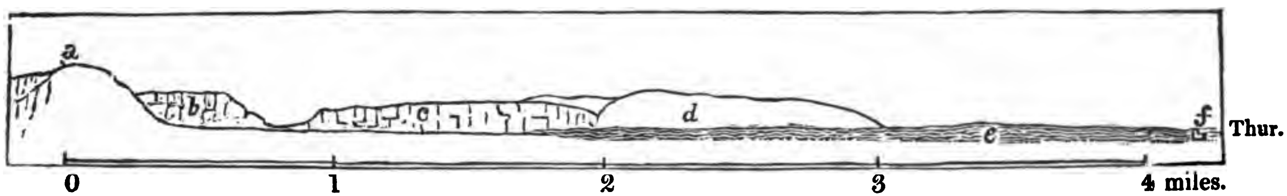
The proof that this overflow of moya was a very sudden one, is shown in the total or nearly total absence of all marks of stratification.

It is probable also that its consolidation was a process proportionally rapid. Thus, for instance, in an eruption of liquid mud, attended even with floods of boiling water, which, so late as the year 1631, had its origin in a subterranean lake of Vesuvius, Scipione Falcone, a writer of that time, has affirmed, that even after a few days had elapsed, the mud had acquired an induration equal to that of a solid rock, and that to break it the assistance of picks was necessary.

Whether any portion of this substance at the time of its eruption was washed away into the lake of Neuwied, we have no evidence to show, although the affirmative is rendered highly probable. It is indeed difficult to conceive of any eruption of mud so great as this, without supposing that much of it would ultimately be swept into contiguous waters.

Such is the brief history of the origin of the tufaceous eruptions of Bell and its vicinity, which will perhaps meet with additional elucidation from the following section. It is drawn from the highest point of the crater-walls of Rieden, not far from which the overflow of moya had its origin, and it ends at Thur, a distance of four miles, where there occurs a great deposit of the tufa, which had been diffused through lacustrine waters.

SECTION FROM THE BRIM OF THE BASIN OF RIEDEN TO THE TUFACEOUS DEPOSIT OF THUR.




*a* Summit of the Gansehals; being the highest point of the brim of the Basin of Rieden.

*b* The Ovenstone of the Gansehals; being the northerly portion of the mass of tufaceous mud which had flowed over the brim of the basin, before it had attained the elevation which it at present displays.

*c* The Ovenstone of Bell, or the southerly portion of the same mass of tufaceous mud.

*d* The Clay-slate Hill which checked the advance of the great mass of tufaceous mud.

*e* The tufaceous strata, which, having been diffused through the lacustrine waters of the Basin of Neuwied, were deposited as far as the present site of the village of Thur.

*f* The village of Thur.

After this very general account of the origin and relative situation of the Ovenstone, the rock may be now considered in detail.

The junction of this tufaceous mass, with the subjacent clay and loam, which had previously subsisted in the ravine, is characterized by an agglutination of various mountain fragments, which, during its course, it had entangled in its substance. To this conglomerate mass, which disappoints the hopes of the quarrymen, the significant name of *Dielstein* is given.

Another appearance presented near Bell, which I did not myself observe, but which I have collected from M. Steininger's rather perplexed description of it, is as follows: The great mass of tufa, in insinuating itself into the ravine, appears by its pressure upon the older beds which it covered to have caused the lower one of clay to start up, which, in its displacement, has insinuated itself on each side of the great volume of the tufa, so as to form a sort of thin layer wedged or jammed in between the overlying mass and the walls of the recipient fissure.

The mineralogical character of the tufa is various. The *Dielstein*, which generally occupies a low place, has been already described.

A second variety, not so coarse, has a base of a greyish, as well as of a hair-brown colour, in which numerous small fragments are interspersed of clay-slate or grauwacke slate, of scales of mica, or of light yellow pumice. Some of the fragments are even in a scorified state.

A third variety has a similar brownish-coloured base, but contains no coarse fragments. Leucite is disseminated through it, though generally in so decomposed a state, that its true character is with difficulty appreciable.

A fourth has a base of a greyish-white milk colour, containing decomposed crystals of felspar, and some of leucite, with small undecomposed fragments of other rocks, generally of clay-slate or of trachyte.

A fifth has a base of a yellowish-grey colour, in which rather fine particles of decomposed felspar, of clay-slate, and even of mica, are discernible; the whole forming a rock which has a structure nearly granular, and not very unlike some of our freestones. It is considered as a valuable diversity of the ovenstone, being well adapted to various purposes connected with domestic architecture. In some specimens which I collected of this rock, I found a tendency to a laminar arrangement.

All these varieties are soft when first extracted from the quar-

ry, and are therefore wrought upon the spot. They subsequently harden, losing at the same time the deepness of their colour.

This rock, as I have observed, is not stratified. It is traversed by cross seams, which resolve it into large angular divisions, often of a very irregular form.

Much of the general contour of these tufaceous mountain masses has been lost during the process of quarrying. Spacious caves are hollowed out in them, the roofs of which are supported by pillars about six or seven yards high.

*3. The lesser overflow of tufaceous mud deposited south of the Ovenstone of Bell.*

It was probably during the considerable overflow of moya, which I have last described, that a small stream of it appears to have found a lodgement a little to the south of the ovenstone of Bell in a ravine or water course, which was perhaps a distinct and more southerly one, but which, farther east, joined that which is now gorged with the larger deposit. From such a point of confluence the common channel would lead to Obermendig and Thur, where the deposit of tufa is found, which had been ultimately diffused among the waters of the basin of Neuwied.

This lesser deposit, which lies about a mile west of Obermendig, is so inconsiderable, the volume of it not boasting many yards in extent, that it merits little notice. Its colour is generally yellowish grey, and it has a consistence or hardness less than that of the ovenstone of Bell. It is evidently compounded of minute or pulverulent particles of trachytic felspar, and in its composition I detected very small portions of white pumice.

*4. The overflow of tufaceous mud deposited near the Hohenstein.*

The Hohenstein is an eminence of clay-slate, the seat of later volcanic explosions, rising to the south-east of the basin of Rieden, between which there is a small irregular valley, where, in

following its windings, we detect a trifling overflow of moya. It is chiefly lodged in a depression to the south-west of the Hohenstein, between this hill and the lofty crater walls of the Hoch Simmer.

This deposit is in some places stratified; whence the inference that its overflow may be attributable to a sort of extravasation, or boiling over, which might have occurred during the earlier accumulation of the muddy contents of the cauldron.

The varieties of tufa here displayed may be briefly noticed. Some of them are remarkable for their similarity to such as are to be found among the lower strata of Rieden.

One variety of tufa is of a yellowish-white colour; of a very fine laminated structure,—brittle also like half-burnt pottery-ware.

A second, a little coarser, and of a yellowish-grey colour, approaches that variety which I have described, (see page 39,) as containing systems of concentric rings of a chesnut-brown colour, like those of some arborescent stem. Here, however, the rings are fewer in number, and they appear more like the sections of seeds of the size of a pea.—But, as I have remarked, a vegetable origin is doubtful.

A third variety has a pulverulent earthy consistence, which is indicated by its soiling woollen when rubbed against it. Some portions of it show an internal prismatic arrangement, like that of dried starch;—the prisms, which are columnar, assuming a similar magnitude and form.

A fourth, and rather coarse variety, approaches to the character of the ovenstone. It is somewhat granular, and contains diffused through it minute portions of trachytic felspar, of clay-slate, or of white pumice.

It is not necessary to dwell longer upon this very insignificant deposit, which is only found in small patches.

### 5. *The overflow of tufaceous mud into an ancient lake extending from the Gansehals to the Lummerfeld.*

We trace a very ancient valley, which has a course nearly parallel to the long diameter of the lake of Laach, from the north-east of the high ridge of the Gansehals to the hill of the Lummerfeld, in the direction of S. W. and N. E.

High ridges of clay-slate bound this valley on the east and west, by which it is separated on the one hand from the Laacher-see, and on the other from the basin of Wehr. Its length is about five and a-half English miles. Its breadth varies much, being near the Gansehals scarcely more than the third of an English mile; and near the Lummerfeld, where it widens, about a mile.

Its depth, particularly about half way between the Gansehals and the Lummerfeld, was originally considerable; and hence the

suspicion which arises, that it was a deep fissure induced during some extraordinary convulsion which had taken place probably at the commencement of the tertiary epoch. It must have existed originally in the state of a mountain lake.

It may, for the sake of distinction, be named THE VALLEY OF GLEIS,—from the village of that name which is situated on its westerly side. (*A portion of it is represented in the wood-cut* page 41, *where it is marked e.*)

From the basin of Rieden this site of an ancient lake is separated by a very narrow ridge; and hence the bed of it must have early received much tufaceous substance from the frequent boiling over of moya, to which the cauldron has been subject. Evidence of a remarkably deep and stratified deposit of this kind may be traced below the westerly flank of the Veitskopf.

This tufaceous substance, from its having been diffused through lacustrine waters, much resembles that which has been deposited under similar circumstances in the basin of Neuwied. It is perhaps in the present instance less mixed with sand, but more with fine clay, and hence its brighter yellow tint, its more pulverulent and earthy aspect, and its still more friable and loose consistence.

But from subsequent drainages of the lake of Gleis, much of its tufa has disappeared, while, from later basaltic eruptions, the character of it in several localities has been considerably modified.

### 6. *The beds of Tufa which lie to the north and west of the Basin of Rieden.*

The earlier eruptions of tufaceous mud to which an evident origin can be assigned have been enumerated. There were no doubt many more which it would be difficult to distinguish from such as might have had a different local origin. It must be kept in view, that during the same epoch two additional and contiguous volcanic craters, namely, of Wehr and of Fusel, gave out mud eruptions, which were probably intermingled with those of Rieden. This is perhaps the origin of some of the beds, resembling the tufa of the interior of the basin, which are deposited thickly on certain contiguous or marginal sites, as, for instance, on those which are to the north-east near Wehr, to the north near the Lierenkopf, or to the west near Weiber.

## SECTION V.—THE ERUPTIONS OF EARLY BASALT WHICH TOOK PLACE AROUND THE BASIN OF RIEDEN.

In a preceding section, the circumstances were investigated under which an accumulation of tufaceous mud, or moya, in a state of ebullition, had been formed within the cavity of Rieden, sufficient to overtop its highest trachytic cones, and to entitle it to the name of a cauldron rather than to that of a common basin.

The causes also, referable in turns to mountain floods and to renewed volcanic eruptions, have been pointed out, which have been followed by various overflows of boiling mud. These I have attempted to trace not only in the lodgement which they might have formed in ancient ravines, but even in their diffusion through lacustrine waters, and in their subsequent deposition.

The latest changes which the basin of Rieden was doomed to undergo arose from renewed eruptions, which were not of trachytic felspar, but of basalt.

It has been supposed that, in general, the earlier products of volcanic convulsions were trachytic, so named from their consisting of felspar of a peculiar roughness or harshness to the touch; and that to these have succeeded eruptions of basalt.

The cause of this very frequent succession, for it is not exactly a constant one, is of most difficult solution. It no doubt bears a reference to the deep-seated and internal constitution of our planet, upon which, in the introductory pages of this memoir, I have hazarded a few observations.

These basaltic eruptions do not appear to have taken place in the interior, but around the circumference of the basin of Rieden. This is a circumstance of perhaps no very difficult explanation. It is not easy to conceive how a basin of this kind should have been formed during the operation of elevating volcanic forces, without supposing that many marginal fissures would be a consequence of the strain; and as the trachytic protrusions which had taken place through the rent of the crater must have been hardened or consolidated, they would afford an effectual resistance to the eruption of new columns of lava, which would now find their elevation and escape to the surface of the earth most favoured through the medium of these marginal rents.

No fewer than twelve eruptions of basalt may be counted which have taken place around the margin of the basin. But owing to the deep deposit of tufa, as well as to the thick sward of grass by which they are much concealed, their relation to the rocks through which they have been protruded is peculiarly obscure. Indeed, a suspicion naturally arises, that some basalt knolls may be completely buried beneath dense beds of tufa, and hence, that the number of them is inappreciable.

On the east of the basin, being at the very brim of it, a point of eruption may be traced, where a stream of basaltic lava has flowed into the valley for a distance of about a quarter of a league. There is also reason to suspect, that about a quarter of a league nearly south of this point, being to the south-east of the basin, another eruption of basalt still more considerable took place, from which a flow has arisen, that has rather bent its course eastward to

the exterior of the valley, as there is here a considerable elevation of the ground, which, from its narrowness, as well as from its being covered over with basalt blocks, points to this circumstance. But the ground is so concealed with a thick sward, as well as with tufaceous debris, that this can be only considered as a plausible conjecture.

On the south of the basin, there are at least three basalt knolls, and if we add to these a high cone of clay-slate, capped with the same volcanic substance lying about a mile due south, or nearly half way in the direction of the Hoch Simmer, the number may be rated at four.

On the west of the basin the eruptions rather indicate a more recent basalt, particularly near Volkesfeld, or at Wabern; and as such they will be noticed in a future page. But on the north-west there are appearances, though ambiguous ones, of an older breaking out.

On the north of the basin, the precise limits of which are to an extraordinary degree obscure, owing to thick beds of tufa, two or three eruptions of basalt, of apparently an ancient date, may be detected.

This is the result of my attempt to determine the sites where the presence of early basalt is manifested. The investigation, for the causes assigned, is in many respects an imperfect one.

Whether any regular crater was formed during these eruptions, there is no unequivocal proof to show. There are some indications which would lead me to suspect, and nothing more, that externally to the south-eastern walls of the basin of Rieden, a considerable one might have very early broken out, of which faint traces, consisting of the hollowed out segment of a large circle marked by layers of a rather darkish-coloured tufa mixed with cinereous particles, are discoverable. On this assumption we might reasonably anticipate, that, owing to the extraordinary and varied convulsions which befel this particular site during the commencement of the tertiary epoch, a loose cinereous fabric could scarcely avoid demolition.

The basalt erupted has almost an uniform character. It here shows its usual greyish black colour, and is particularly hard. It contains in its composition a larger proportion than common of felspar, which might indeed be expected from its having immediately supervened to trachytic eruptions. There are also thinly disseminated in its base, which is homogeneous, small crystals of augite or pyroxene, by which it is entitled, agreeably to Brongniart's nomenclature, to the name of *Basanite.*

In one or two places only could I detect any vitrification in the

rock. I observed small portions of it in this state on the north of the valley, and I collected a few scorified fragments as well as cinders from the upper strata of the interior of the basin of Rieden; the presence of the latter giving fresh grounds for the suspicion, that one or perhaps more craters might have broken out on its margin.

These basaltic eruptions, which can only be traced to the exterior of the basin, appear in some places to have caused considerable disturbance to its tufaceous contents. This is shown more particularly on the east side, where the pre-existing strata appear in many spots greatly shattered. That most of the tufa was in a soft state when the basalt was protruded, is evinced in some of the strata which contain imbedded in them cinereous portions of basalt, the largest of which are about the dimensions of an inch and a half. And where the same tufa is found in junction with the basalt, it appears so altered by the heated mass, as to vie with the hardness of trachytic porphyry. It is of a yellowish brown colour, varied with specks of the same tint of a lighter shade. The cinders contained in it have been by the power of heat so firmly agglutinated in the mass, as to almost appear a part of its substance; their line of circumscription becoming proportionally indistinct.

But the greatest change induced in the valley of Rieden remains yet to be explained. Later invasions of volcanic rocks, which were protruded from the very brim of the basin, had caused in many places such an addition to the height of the walls, that the original drain from the south-east became resisted by the intervention of a far loftier bulwark, over which any new overflow would have failed in effecting its escape. The more elevated point of the Gansehals, which now boasts a height of 1643 feet above the level of the Rhine, must have aided in producing this result.

The first consequence of this change was, that an increased capacity was given to the basin, which from this time would begin to be filled with tufa resulting from the wearing away of its marginal rocks of basalt. The decomposed substance induced, which was of a dark colour, readily became mixed with the disintegrated materials of pre-existing and lighter-coloured tufaceous strata, and hence the varied character of many of the upper beds of the tufa of Rieden, particularly on the south side. They are of a soft, loose consistence, of a very dark colour when first quarried, but growing paler after long exposure to the sun.

A second consequence would be, that any future overflow would be compelled to effect its discharge through some new formed channel. From this time, then, may be dated the commencement of a new ravine for the drainage of the valley on the south-west of

the basin, by which its overflows were conducted into the ancient stream of the Nette.

Subsequently to this event, the basin of Rieden was doomed to experience no farther volcanic eruption. Little, therefore, remains to be recorded of its future history, except the appearances resulting from the gradually deepening corrosion of its new channel of drainage.

In the course of a period which admits of no calculation when attempted to be measured by historical annals, long corrosions have reduced the newer channel of drainage to its present depth. It is, notwithstanding, still so narrow, indicative, perhaps, of its comparatively recent origin, that it would be no difficult task to form an artificial barrier to the drainage of the valley, to lay the present unsightly village under water, and to convert the more elevated cones into a beautiful archipelago of wooded islets.

Coincident also with the drainage of this basin was the removal of its beds of tufa, and the exposure of its trachytic cones once submerged under a deep accumulation of boiling mud. Accordingly, in ascending a high point west of the Gansehals, we look down upon a most irregular fissure or cavity, exhibiting in its outline a thousand different forms, in the interior of which numberless volcanic peaks start up, the sides of which, as well as of the walls of the basin, are in general lined with thick strata of tufa, the remains of an upfilling mass, which in the course of ages has been removed by disintegrating causes, and carried away by mountain torrents. *(See Plate V.)*

## Section VI.—General remarks on mud volcanos, suggested by the phenomena of the basin of Rieden.

In the three foregoing sections, we were required to conceive of the focus of a volcano, in which many minute and light pulverulent particles were elaborated, being called into action beneath an abyss half-filled with incandescent lava, into which flowed various mountain streams. Under these circumstances it was added, that the superambient waters of the lake would intercept all the light particles of volcanic matter, which would otherwise have been projected high in the air, and widely dispersed over a large surface of territory, causing them to be mingled with water of a temperature highly elevated from its contact with incandescent lava;—and that the mixture would then assume the consistence and character of a liquid mud.

The contemplation of a process like this, which, in a basin like that of Rieden, some miles in extent, has caused every space unoccupied by its protruded trachytes to be filled with a tufaceous mud, becomes not a little astounding; our surprise being increas-

PLATE V.

The valley of [illegible]

[illegible]

ed by the fact, that overflows from this deposit have filled adjoining vallies, and have even been diffused among the lacustrine waters of the basin of Neuwied. A question, then, which irresistibly intrudes itself, is,—Have the causes in operation been really equal to the accumulation of these suspended earthy materials to such an amount?

To this question an unhesitating answer may be given. So infinitely great is the amount of light pulverulent particles which modern volcanos during their activity have given out, that, when carried into the atmosphere, they have formed clouds so thick as to deprive extended regions of the light of day. For instance, in the year 1794, during an eruption of Vesuvius, Calabria had its atmosphere entirely obscured by the light cinereous particles which were propelled;—again, on the authority of Procopius, we are assured, that at a prior period, namely, in the year 472, so vast was the abundance of them, that they were diffused over remote countries, as far even as Constantinople. Let us then suppose that a similar elaboration of the light pumiceous or pulverulent particles of trachyte should have taken place from a volcanic vent which a deep lake had submerged; and we have a cause perfectly adequate to explain, why, in their interception by lacustrine waters, and in their diffusion through them, a basin so capacious as that of Rieden should have been filled even to an overflow with tufaceous mud or moya.

With respect to the sources of the immense supply of water, in which a corresponding proportion of pulverulent materials has been suspended, there is comparatively little difficulty. It is evident that the water might exist under more circumstances than one.

In the first place, craters induced by volcanic agency often become gradually filled with water; and as the more ancient ones must have been the result of an energy exceeding what is manifested at the present day, lacustrine sites, commensurate with the greater extent of the basins induced, would, in the course of new eruptions, be filled with boiling mud.

In the second place, the source of aqueous supply may often be traced to pre-existing inland lakes, beneath the beds of which volcanos have burst forth, accompanied with the formation of craters and the ejection of pulverulent matter, which has consequently been diffused through the waters. This fact is illustrated in the numerous basins necessarily coincident with recently elevated lands, few of which would possess incipient outlets for their drainage; and hence the many mountain masses of tufa which may be referred to accumulations of volcanic mud unable to effect their escape, and which have consequently been diffused over nearly the whole extent of a lake, frequently in almost incredible depths.

Striking illustrations of this fact may be found in the Mont Dor and the Cantal of the south of France, or in the vicinity of Albano in Italy. The immense beds of tufa at the Bay of Naples had their origin in circumstances perfectly analogous, namely, in the trachytic volcano of Monte Somma first bursting forth amidst the waters of an estuary rather than of an inland lake.

Lastly, the source of aqueous supply may be often traced to large fissures formed in the interior of a mountain, either during the elevations and subsidencies of volcanic convulsions, or from the long corrosion of percolating waters. Thus, it is recorded of Vesuvius, that in the year 1751 a stream of water so immense issued from a fissure into which rains or snow had percolated, as to acquire the name of the *Nilo d' Acqua*. And when volcanic mountains attain an elevation approaching the line of perpetual congelation, accumulated masses of snow melted by volcanic heat have been known to find their way into caverns so vast, as to form ample subterranean lakes, compatible with animal as well as vegetable existence. In the year 1698, a lake in the interior of the mountain of Carquarazo, which, during volcanic paroxysms, had been filled with pulverulent matter, burst and covered over a space of country to the extent of eighteen square leagues with a boiling mud, in which fish were inclosed. The substance thus ejected, which first in South America received the name of *Moya*, is said to have resembled in consistence *bouillie*, and to have hardened upon cooling.

These observations I have deemed fit to make from their being calculated to show, that the phenomena of mud deposits are less to be regarded as belonging to the rarer incidents of ancient or recent eruptions, than to those which are among the most familiar ones in volcanic history.

M. Steininger of Treves has been the first who named the tufa of the vicinity of Bell, as well as of other places, a mud eruption. But he has neither been able to point out its true origin, nor to see its necessary dependence upon some contiguous crater lake. He has been content with referring its elaboration to the volcanic focus itself, conceiving that it had the self-same origin as an incandescent lava stream. This geologist has been opposed by many writers, among whom might be cited Dr Daubeny. (*Daubeny on Volcanos*, p. 60, &c.) One of the objections of this last named author is from " the want of connection which the tufa has with neighbouring craters." But Dr Daubeny is not the only geologist who has failed in seeing this connection. Amidst the volumes which have been written upon the volcanos of the Lower Rheinland, it is not a little remarkable, that the information which has been hitherto collected of the basin of Rieden, of its immense trachytic eruptions, or of its accumulations of tufa, is so scanty,

that the whole of it might be contained within the compass of half a page. It is surely time, then, that its pre-eminence over almost every volcano in the Lower Rheinland should be duly appreciated.

## CHAPTER VII.

### THE TRACHYTIC ERUPTIONS NEAR THE SOURCE OF THE BRUHL.

THE valley of Brühl, as we trace it from its principal source near the hill which commands the village of Hahnenbach to the Lummerfeld, near Burg Brühl, has been already considered as a deep fissure bounded by precipitous cliffs, which having been originally closed to the east, formed a very irregular fresh water expanse. The wearing down of the barrier north of the Lummerfeld, by which its waters were conducted into another fissure opposed to it at nearly right angles, and thence into the channel of the Rhine, must be considered as a much later process, to which our attention is not at present invited.

Connected with the valley of the Brühl are several channels for the subsidiary streams which flowed into this ancient lake. They are no fewer than five in number, running from S. W. to N. E., and appearing to have owed their earliest form to corrosion. Whether they were subsequently deepened by any extraordinary convulsion is questionable.

At the sources of several of these subsidiary streams, we find eruptions of trachytic felspar, or craters actually formed. These are, 1*st*, the crater of Fusel; 2*dly*, the crater of Wehr; 3*dly*, the eruptions of the hill near the village of Hahnenbach, and of several small conical eminences to the south of it; and, 4*thly*, the eruption of the hill of Olbruck.

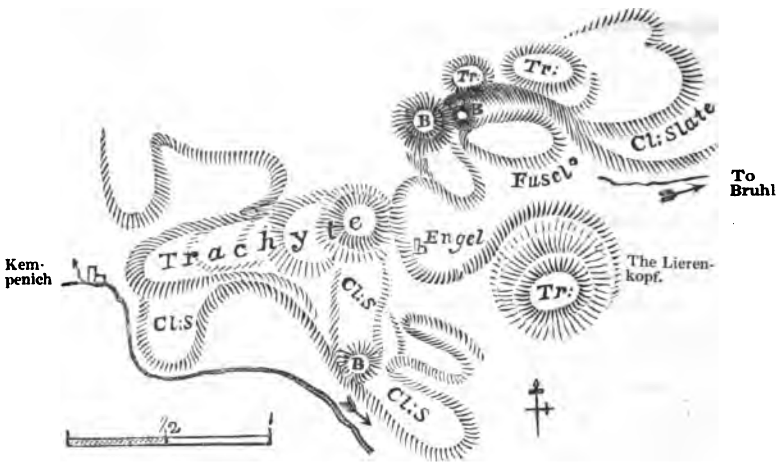
These will be described in succession.

#### SECTION I.—THE VOLCANIC BASIN OF FUSEL.

The volcanic basin of Fusel has a date either exactly contemporaneous, or very nearly so, with that of Rieden, from which it is situated about a mile north-west by north. A cluster of miserable cottages is contained within this extinct crater, to which the name of *Fusel* is given. But a more correct orthography is that which is suggested by M. Steininger, viz. *Fuchshöhle,* significant of the foxes' hole.

Upon an eminence forming the south-westerly wall of this basin, the village of Engel is situated.

But to better explain the geography of this basin, the following sketch is annexed:




In this plan the various rocks are distinguished by letters, either as trachyte (*Tr.*); of more recent basalt (*B.*); or of clay-slate (*Cl. s.*); while it is understood that over nearly the whole is to be found a tufaceous coating.

The history of the basin of Fusel is almost the same as that of Rieden:—It has been a volcanic crater;—it has been the seat of trachytic eruptions;—and it has been filled with a tufaceous mud. A basaltic eruption also appears, but as this is of a date much later than that of Rieden, it will be described in a future chapter.

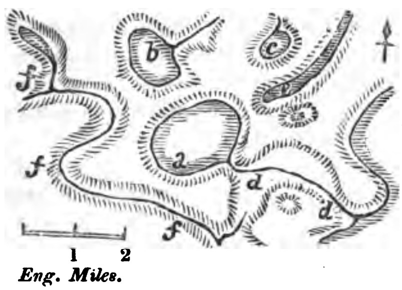
(*a.*) *The formation of the Crater of Fusel.*

The crater of Fusel, like that of Rieden, or Laach, was no doubt formed during the incipient liberation of elastic gases. Owing to supervening trachytic eruptions, its pristine limits are not well expressed. Its form is at present very irregular. In length it is about half, and in breadth about a quarter of a league. It is closed on the south-west and it opens out to the north-east; being drained by a stream, which, taking its rise from this point, joins the river Brühl at the distance of a league or more at Ober-Zissen. Originally, the valley was closed in to the north-east, and consequently undrained;—which circumstance must be kept in view during our present investigation.

The fragmentary debris thrown up during the liberation of elastic gases has no doubt in part disappeared within the unfathomable profundity which had been formed, or has in part been re-

moved by the operation of the diluvial torrents incidental to this disturbed epoch.

But perhaps the best notion of the situation and original form of the basin of Fusel will be conveyed by again bringing before the view of the reader the slight sketch illustrative of the Tertiary Geography of the vicinity of Rieden which was given in page 41.




In this repetition of the sketch it is sufficient to state, that while the basin of Rieden is designated by the letter *a*, that of Fusel is indicated by the letter *b*. The stream on the north-east of the basin is also marked by which it has been subsequently drained. Farther to the north-east, this ravine is lost in the channel of the Brühl. *(See the general Map, Plate I.)*

(*b.*) *The Trachytic Eruptions of the Basin of Fusel.*

That the basin of Fusel had its original limits greatly circumscribed by protruding eruptions of trachyte, there can be no doubt. A trachytic hill, for instance, named the Lierenkopf, situated on the south-east, has added considerably to the space intervening between the basins of Fusel and Rieden.

Many of the points of eruption incidental to the crater of Fusel are with difficulty traced amidst the deep beds of tufa with which they are coated over. In other instances, the felspathose rocks are sufficiently manifest, particularly upon the Lierenkopf, as well as upon a high cone between the Engelerkopf and Olbruck, and on the ridge dividing the basin of Fusel from the valley of Kempenich.

Some eruptions may be detected on one or two points of the ridge which overhangs on the north the cluster of cottages already described. The base of these volcanic rocks is a very compact phonolitic felspar, (perhaps corresponding to Brongniart's leucostine,) of a yellowish grey colour, showing a clear fracture, which approaches to the conchoidal. Numerous small crystals of leucite are interspersed through it, which rarely exceed the magnitude of millet seed; but they are so much changed in their texture, probably from being acted upon by heat, as to appear in the state of a

kaolin, and to fall away during decomposition, leaving minute cavities on the surface of the rock. Very small crystals of glassy felspar may likewise be detected, but they are much more rare.

From a hill west by north of the contiguous village of Engel, separating the valley of Fusel from the valley of Kempenich, a similar eruption, of great magnitude, may be traced along a ridge of rocks stretching in a direction east by north to west by south for a distance of half a league. The trachyte closely resembles the last described; except that it contains fewer crystals of leucite and is not so decomposable, whence perhaps its darker or more decided shade of colour. Minute crystals of hornblende may be detected in it.

### (c.) *The Tufaceous Deposit accumulated within the Basin of Fusel.*

In explaining the volcanic appearance of the basin of Fusel, we are required, as in the example of Rieden, to conceive of the focus of a volcano in which many minute and light pulverulent particles were elaborated, being called into action beneath an abyss from which lava was protruded, and into which flowed various mountain streams. Under these circumstances, the crater-lake of Fusel must have evidently intercepted the light particles of volcanic matter which would otherwise have been dispersed high in the air, causing them to be mingled with water of a temperature highly elevated from its contact with incandescent lava, and to assume the consistence and character of a boiling mud.

The tufaceous deposit of Fusel displays evident marks of this origin. An increase to its mass has been caused by the chemical action which water impregnated with saline matters, and of an increased temperature, has been enabled to exert upon the protruded felspathose rocks. Accordingly, these will be found in many places to be decomposed to some little depth, giving rise to the particles or even larger fragments of trachyte which are intermingled with the tufa in an altered state.

The deeper seated tufa may in general be considered as the hardest variety. It is of a yellowish-brown colour, of a rough aspect and feel, and contains in some places small pores. Incorporated with the base are numerous minute fragments of volcanic cinders or pomice. When the small fragments which enter into its composition have been only in part reduced to a state of decomposition, they often exhibit the form of a brownish-coloured nucleus surrounded by whitish earthy matter, which gives to the whole a very mottled or diversified appearance. Minute fragments of decomposed clay-slate, as well as small scales of mica, may be likewise detected in the tufa. The substance thus de-

scribed shows little of a stratified appearance. It is found, among other places, on a hill north of the cottages to which the name of Fusel is specially applied.

The rest of the tufa, which exhibits more decided marks of stratification, is of a less hard consistence, of a very earthy aspect, and is either of a dull yellowish-brown, or of a wax-yellow colour. In some of the strata we meet with small fragments of pumice disposed in regular layers. There is also diffused through the whole minute fragments of clay-slate, or detached crystals of leucite, hornblende, or other mineral substances incidental to the strata which are broken through, and the nature of the erupted matter.

Such is the deposit of tufa which is discovered mantling the summits of all the hills surrounding the basin of Fusel, showing that before the drainage of its waters was effected, an accumulation of moya must have completely filled the volcanic cavity.

### (d.) *The Overflows of Tufaceous Mud, or Moya, from the Crater of Fusel.*

The causes giving rise to overflows of tufaceous mud from crater lakes have been referred to periodical or occasional floods of water swelling the volume of the muddy contents of the basin, as well as to the displacement of the turbid mass by renewed eruptions of lava;—whence its consequent extravasation over the edges of the boiling cauldron. In the instance of the crater of Fusel there is little doubt but that both these causes have conspired to produce the overflows of tufaceous mud which may be detected. These we shall now describe.

In a deep lateral valley of the Brühl, to the south of the isolated eminence upon which the castle of Olbruck is built, a yellowish-coloured deposit of tufa may be observed, of an evident felspathose character; which is referable to an extravasation of moya over the northerly walls of the crater of Fusel.

There are also marks of a similar overflow which has taken place from the north westerly walls of the basin. Having fallen into the valley of Kempenich, whence the Nette takes its rise, the tufa now lines the northerly base of the volcanic ridge over which it was extravasated.

Lastly, as a natural drainage of the crater lake appears to have very early commenced on the north-east of it, we are authorized in referring some part of the tufa which has choked up the valley of the Bruhl near Nieder-Zissen, to the escape of moya through this channel of drainage during its incipient state.

During the course of a long geological epoch this channel of drainage has been gradually deepened, so that the far greater portion of the upfilling mass of tufa has been eventually removed. We

accordingly find that the little which is left continues attached to rocks of clay-slate and trachyte, or that it forms a small circular elevation, or mound, of tufa, which, to the north and north-west of the village of Fusel, occupies the bottom of the basin.

### Section II.—The volcanic basin of Wehr.

In the present section it is proposed to explain, *1st*, the volcanic basin of Wehr; *2dly*, the felspathose rocks of volcanic origin which were protruded; and, *3dly*, the tufa with which the basin was filled.

#### (*a.*) *The Origin of the Volcanic Basin of Wehr.*

The basin of Wehr, like that of Laach, of Rieden, or of Fusel, was one of the original craters of this district, formed during the commencement of the tertiary epoch by the disengagement of elastic fluids, to which felspathose or trachytic eruptions supervened. No debris is accumulated on the sides of the crater; for which reason we must conclude, as in other analogous instances cited, that the shattered fragments of clay-slate thrown up have disappeared in the unfathomable abyss induced, as well as been swept away by the diluvial agents which were then in activity.

The crater of Wehr is of an oval form; its largest diameter, which is from north to south, being about a mile, while its shortest diameter, from east to west, is about half a mile in extent. As there was originally no outlet for the waters, (the gorge on the northerly extremity by which it is at present drained having been the result of a subsequent process of erosion,) it would soon be converted into a crater lake.

#### *2dly, The Felspathose Rocks of Volcanic origin which were protruded.*

Whether any felspathose rocks of volcanic origin were protruded from the vent of the crater of Wehr, resembling those of Rieden, can only be the subject of conjecture. The bottom of the basin in its present state exhibits an undrained swamp, and so deep is the accumulation of bog within it, that if there had ever been any protrusion of trachytic rocks from below, we must regard them as concealed beneath an impenetrable morass. Under these circumstances, we are only sanctioned by analogy in the supposition, that from the depths of the crater of Wehr trachytic eruptions might have protruded.

But on examining the margin of the basin our researches are somewhat more successful. A hill upon the east of the ravine which forms the northerly gorge of the basin displays traces, notwithstanding the covered state of the ground, of the eruption of felspathose rocks, numerous fragments of which are dispersed

over the surface of the elevation ; and as portions of mica-slate are obtained in this site, it may be presumed that the protruded rock, before arriving at the clay-slate, had first pierced a bed of micaceous schist.

The specimens of felspathose rocks which are displayed in the form of strewed and detached fragments, I shall now describe.

The first of these is of a greenish black colour, and of a very compact and firm structure, somewhat resembling what continental writers might call a greenish coloured eurite, or perhaps an ophite. In the present instance, it may be described as a mandelstein, containing within it minute round cavities filled with chalcedony, about the dimensions of millet-seed. Some few larger cavities may also be detected in it, perhaps about an inch or more in their dimensions, which are geodes thinly lined with needle zeolite.

A second rock has a compact euritic base of a lighter and brighter shade than the preceding, with a colour rather of a blackish green, than of a greenish black. It is thickly studded with whitish or reddish white concretions of leucite, about the size of millet-seed, the crystalline forms of which, from their circumference being so incorporated with the substance of their base, are very indistinct. There may also be detected in this rock, though very sparingly, minute crystals of glassy felspar.

There is again a second variety of the same leucitic greenstone, in which the forms of the grains of leucite become still more indistinct from their intermixture with the substance of their base.

Lastly, a rock occurs having a base of a leek-green colour, the structure of which is equally compact with the previously described varieties; but it differs from the two last in containing no leucite, in the place of which small crystals of glassy felspar are thickly interspersed.

Such are the more ancient felspathose eruptions characteristic of the margin of the basin of Wehr. Others might probably be discovered, at present concealed amidst the immense quantity of tufa, or the depth of green sward with which the heights and sides of the basin are lined.

(c.) *The Tufa with which the Basin was filled.*

The evidence of felspathose matter having been abundantly projected in a pulverulent form, and intercepted by the waters of a crater lake, is afforded in the appearance of the tufa which lines the very brim of the crater, and which indicates that the basin was once filled with boiling mud.

The tufa is of an ochreous or cream-yellow colour, differing little from that of Rieden. It is in some places so hard, as to be quarried for domestic or architectural purposes.

Some portion of this accumulation may, however, be indebted to the overflowings of moya from adjoining craters.

In examining the northerly margins of the basins of Rieden or Fusel, it is impossible not to be struck with the great height at which the tufa lies. It may be found on all the high ground intervening between the basins of Rieden, Fusel, and Wehr, whence there can be little doubt but that the latter basin has received much of the tufaceous matter ejected by the former. It is from this cause possibly that the basin of Wehr has again in its turn overflowed, whence the deep bed of tufa which may be found on the easterly and lower side of it, as well as upon the ridge by which it is divided from the nearly parallel valley of Gleis, where it dips a little towards the west.

As a drainage must also have very early commenced on the north of this basin, it is not improbable that overflows of moya were very early conducted by this original channel into the ancient ravine of the Brühl, where we find the remains of a considerable tufaceous accumulation. Thus, in that part of the channel of the river which lies beneath the Bausenberg, we find a conglomerated deposit consisting of tufa blended with sparing minute portions of white pumice, with which are intermingled river sand and clay, together with numerous rolled fragments of stones. In the lower beds the pure tufa prevails. It is proper, however, to add, that much of this accumulation is indebted to other volcanic sources, as well as to subsequent processes of transportation.

### Section III.—The eruptions of the hill which rises above the village of Hahnenbach, and those of the small conical eminences to the south of it.

The circumstances attending these eruptions rather differ from the preceding ones described, in as much as no proof is afforded us that an actual crater was induced. We shall accordingly consider, *first*, the protrusions of felspathose rocks which ensued, and, *secondly*, the origin of the tufa with which the ancient lake of the Brühl was filled.

#### 1*st*, *The Protrusions of Felspathose Rocks.*

The elastic fluids generated in the volcanic focus have not been so great as to produce for their disengagement a crater-form opening, but they have been enabled, by their pressure upon the interior fluid mass of the globe, to propel, through fissures made in its exterior crust, columns of incandescent lava, which, having attained a small height above the orifice whence they have issued, have subsided, agreeably to the process which has been already explained, in the form of conical elevations.—*(See page 30.)* These elevations are exhibited in the hill which commands the village of Hahnenbach, and in certain conical eminences to the south of it. They will be considered in succession.

(*a*.) THE HILL WHICH RISES ABOVE THE VILLAGE OF HAHNENBACH.—The hill which rises above the village of Hahnenbach bears, I believe, the name of the Perlenkopf. It commands the highest source of the stream of the Bruhl, which was originally expanded into the form of a deep and irregular lake.

In breaking through the strata of clay-slate, of which this hill is composed, volcanic matter has not only capped the summit of it, but has flowed down its southerly declivity in the form of a thick stream of lava.

This volcanic rock consists of granular particles of felspar, exhibiting different shades of a light brownish red colour, in which minute crystals of hornblende are thickly disseminated. Frequently, however, this last named ingredient rather approaches to the mineralogical character of pyroxene. In other places we trace undoubted crystals of basaltic hornblende. When the hornblende or pyroxene (for its true character is but too often doubtful) less prevails, the rock, as we might expect, loses the predominance of its darker tint, and assumes a mottled reddish hue. Another feature of it is, that innumerable pores pervade every part of it, which even cause it to occasionally approach to the character of a slag. On account of this porosity, the rock is tolerably well adapted for millstones, for which it has long been quarried. Considerable seams traverse it, by which it is resolved into large angular fragments, often of a cubic form, which also in a few sites show a tendency to put on the form of large globular concretions.*

(*b*.) THE TRACHYTIC ERUPTIONS TO THE SOUTH OF THE HAHNENBACH HILLS.—On the south of the hill which rises above Hahnenbach, soon after quitting its lava flow, and after crossing a little stream which feeds the Brühl, we may discover several small eminences, almost wholly concealed by a tufaceous upfilling of the valley, which indicate other felspathose eruptions. These must have taken place within the actual limits of the ancient lake of the Brühl.

The felspar of one eruption has a base of a dull olive green tint, and of a rough and uneven fracture, in which are disseminated, though rather sparingly, minute crystals of leucite and felspar, the latter being either vitreous, or reduced, probably by the action of heat, to the state of a kaolin.

The eruptive matter of another small eminence, to the east of the last described, consists of a reddish brown felspar, which has rather a slaty structure. The surface of the laminæ is very rough to the touch. Small crystals of glassy felspar and hornblende are sparingly disseminated through it. Probably this rock may correspond with M. Brongniart's *leucostine schistoide*.

* This rock scarcely identifies itself with any description cited by M. Brongniart. It may perhaps be considered as a Tephrine.

Having described the eruptions of Hahnenbach and the hills adjoining to it, we shall consider,

*2dly, The Tufa with which the ancient Lake of the Brühl was filled.*

The felspathose eruptions, which have been described, must have been assuredly accompanied with the disengagement of pulverulent matter from one or more subaqueous openings or vents, which, having been intercepted by the waters of the Brühl, would fill the lake with a tufaceous mud. Accordingly, we find that tufa not only mantles the south side of the Hahnenbach hill, but that it may be even traced to the summits of the small eminences just described.

Much of the tufa is of a yellowish colour, and of a less firm consistence, as might be expected from the pulverulent substance which composes it having been diffused through the waters of a lake, and perhaps intermingled in some little degree with a lacustrine deposit of plastic clay or fine sand. Near the Hahnenbach hill we observe a tufa of a more dark shade than usual, indicative of the deeper tint of the rock whence it has resulted. Its colour may be described as a light blackish grey. Besides containing minute fragments of clay-slate, it incloses scales of mica.

At some farther distance from the source of the Brühl the tufa becomes even coarser, indicative of its having been derived from more sources than one. Besides being composed of the pulverulent felspathose matter which has been ejected and diffused through these waters, or of the sandy or argillaceous deposit proper to the lake itself, it is mingled with fragments of clay-slate conveyed by subsidiary streams, or with the overflowings of tufaceous mud, or moya, in a state of ebullition derived from the craters of Fusel or Wehr; or even with the debris of indurated tufa, or trachyte, subsequently acted upon by torrents, and carried through various channels into this common lacustrine basin.

Owing to these varied circumstances, the tufa which was formed, and which we trace as far east as Nieder Zissen or Burg Brühl, approaches to the character of a conglomerate rock. It has a base of decomposed felspar mixed with sand and clay, and is of a dirty and dull wax-yellow colour. It is either fraught with particles of yellow pumice about the size of peas, or with portions of clay-slate more or less altered by decomposition.

## Section IV.—The Volcanic Eruption of the Hill of Olbruck.

Another felspathose eruption is from the insulated hill of Olbruck. The volcanic rock which crowns its summit is of a yellowish grey colour; it has a compact texture, and a fracture approaching to the conchoidal. Disseminated through it, though

rather sparingly, are small crystals of hornblende. Crystals of glassy felspar are much more rare, and still more so are those of quartz, one or two individuals of which I detected in a hand specimen of the rock.

Owing to the surface of the hill of Olbruck having been greatly disturbed when the foundations were laid of the strong castle and keep which adorn its summit, it is difficult to say whether or not it exhibited the appearance of a very small crater, or whether the tufa which is found upon it is the result of an upfilling of tufaceous mud, or of the gradual decomposition of trachytic felspar.

The tufa which I collected was of a dull cream-yellow colour, of a firm consistence, and of a rough earthy fracture. Besides the small crystals of hornblende and of glassy felspar which it contained, there were dispersed through it minute scales of black mica, and some very small fragments of clay-slate.

Below the hill of Olbruck, on the south side of it, are strata of felspathose tufa which must be regarded as a portion of the general mass which filled the valley of the Brühl. The darker coloured tufa by which it is surmounted has its origin in a much later eruption consisting of basalt. This will be described hereafter.

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These are the whole of the felspathose or trachytic eruptions near the sources of the Brühl which have fallen under my notice. The basaltic eruptions which occur interspersed through this limited district are of a much more recent date, and will therefore be explained in a subsequent chapter.

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## CHAPTER VIII.

### THE ERUPTIONS OF TRACHYTIC FELSPAR AND EARLY BASALT OCCURRING ON THE WESTERLY HEIGHTS WHENCE THE RIVER NETTE DERIVES ITS ORIGIN.

THE line of mountain elevation, which it is now proposed to investigate, is in the range of the Eifel, being situated north of the High Kelberg. This lofty hill commands another valley, and is consequently removed from the limits of the district to which I have confined myself. As a description of it cannot therefore with propriety be attached to this narrative, I shall merely remark that the eruption of felspathose matter with which its flanks are covered, may, I think, be considered as one of the oldest in the Lower

Rheinland. The trachyte which may be thus observed is of a brownish or reddish brown colour, and seems to contain in its felspathose base much ferruginous matter, in which crystals of glassy felspar are interspersed. In some places it is decomposed, exhibiting in this respect a faint similarity to the rock of the Puy de Dome, whence the epithet of domite, which has been applied to it. Besides this rock, a phonolite of a greyish colour is discoverable, which, in the language of Brongniart, may perhaps be considered as a compact leucostine. Lastly, an eruption of early basalt, beautifully disposed in prismatic columns, is observable on the northerly flank of the hill.

With these very slight remarks on a hill of great geological interest, to which I have only digressed from its contiguity to the Nurburg and the High Acht, I shall content myself. The mountain range which I propose to describe is separated from it by a slate ridge and valley. This valley may be traced, with perhaps some slight deviations, in a northerly direction for a distance of two to three leagues to the hill of the Nurburg, and thence north east to the High Acht. The high land to the east of this valley, which we are required to investigate, appears to have been far advanced in elevation above the surface of the large lake which occupied the lower levels of the Mayenfeld and the plains of Neuwied.

The volcanos to be found in this commanding situation are as follows: 1*st*, those to the south of the Nurburg; 2*dly*, the eruptions of the Nurburg; 3*dly*, the High Acht; 4*thly*, the minor basaltic eruptions in the vicinity of the Nurburg and the High Acht; and 5*thly*, the crater of Boos.

### Section I.—The Eruptions to the south of the Nurburg.

The eruptions which we trace on the south of the Nurburg consist of, *first*, a crater, the walls of which are composed of trachyte; *secondly*, of dikes of greenstone; and, *thirdly*, of knolls of basalt. These will be described in succession.

#### (*a*.) *The Trachytic Crater situated to the south of the Nurburg.*

This crater appears to have broken out amidst the waters of a small mountain lake or pool.

Upon the high terrace on which the eruptions to the south of the Nurburg may be traced, a depression of the land is observable, which, from the fine quartzose sand to be detected in it, similar to that of the basins of Neuwied and Cologne, gives indication of the ancient site of a small lake. The overflow from this pool must have found a discharge in the deep channels of the Nette towards Virneberg, whence it would be prolonged in an easterly direction, until, near Mayen, it would join the waters of the lake of Neuwied.

Such was the original lacustrine site of this crater, the walls of which, though not entire, still indicate its limits. Their height is inconsiderable. They appear composed of trachytic fragments mixed with the fine lake sand which was at the same time thrown up.

The crater in its form gives some indications of having been a double one; its walls showing a tendency to a concentric arangement, and indicating that two successive eruptions had taken place on this site. At the same time, the appearance is somewhat ambiguous, as the walls of the crater, from the effects of disintegrating agents, have evidently undergone a material change in their form.

The site of ground occupied by this crater approaches to an oval form, its long diameter amounting to perhaps more than half a mile in extent.

The volcanic fragments may be next described, which, along with lake sand, form the structure of the crater walls. The base of them is a felspar, somewhat porous, which displays two or three tints of colour. The least decomposed fragments have a bluish grey base; other specimens rather weathered, have a yellow ochreous tint. These two varieties again show fainter shades of colour until they approach to perfect paleness. Crystals of glassy felspar are disseminated through their base, which vary much in size, from the tenth part of an inch to half an inch or more. Minute crystals of hornblende and small scales of mica may also be detected; but these last are very sparing diffusions. When the trachyte is much weathered, it resembles in some degree the supposed domite of the Kelberg.

The trachyte in its protrusion, before piercing strata of clay-slate or grauwacke, must have penetrated a subjacent rock of granite, which is evident from the scattered fragments of it which I discovered. This substance is almost wholly composed of semicrystalline grains of felspar and quartz of a moderate size, and of a whitish colour, the former being more distinct than the latter, through which very minute crystals of hornblende are interspersed.

These remarks on the trachytic crater south of the Nurburg are perhaps sufficient. It may be added, that, subsequently to the obliteration of the ancient lake in which the crater broke out, its interior long continued to afford a lodgement for waters. But, lately, this volcanic basin has undergone an artificial drainage, and instead of containing within its walls a shallow pool, we observe issuing from it a trivial stream, which, in directing its course towards the Nette, is regarded as the chief source of this river.

*(b.) The contiguous eruption, in the form of a dike, of a rock resembling Greenstone or Trap.*

West of the crater which I have described may be observed,

rising from the green sward, some knolls of a rock resembling greenstone or trap, indicative of an eruption in the form of a continuous dike. This dike must have been of rather a later date than the crater, as there is reason to conclude that it has broken through one of its walls so as to affect its integrity.

The rock thus erupted very much resembles in its general appearance some varieties of argillaceous schist. It has a homogeneous base of a blackish-grey colour. Its texture is very compact. It has rather a tendency to a laminated structure, and when broken in the direction of its fissility, exhibits on its surface minute shining points, which, at first view, appear like mica, but, on examination, show that they are nothing more than resplendent particles of the substance of the stone itself. By a cross fracture this appearance is rendered evanescent, and a conchoidal fracture is in part produced. In some specimens I detected very small amygdaloidal concretions, perhaps indicative of its subaqueous protrusion, consisting of chalcedony. The rock is much intersected by cross fissures that divide it into angular fragments approaching to rhomboids, the dimensions of some of which I found to be three or four inches. The fragments thus induced are coated on their joints by a substance of a greyish-white colour, which is evidently decomposed felspar.

To this rock it is difficult to assign a name that may be satisfactory to certain new nomenclatures. As it appears to possess a hard, compact, and homogeneous base, chiefly composed of felspar, with perhaps a slight intermixture of the substance of hornblende, it corresponds with the definition which M. D'Halloy has given of *trap*, viz. that of "a rock with an apparently simple base, which appears to be a mixture of hornblende and felspar, harder than aphanite," or homogeneous greenstone. On the other hand, it is not improbable, from its association with trachyte, that it would by some mineralogists acquire the name of a schistoid leucostine.

### (c.) *The Basaltic eruptions south of the Nurburg.*

On the summit of a ridge to the south of the crater which I have described, a tolerably sized knoll of early basalt appears; and if from this point we proceed west and north of the crater, towards the Nurburg, we shall find in the boundary of the plateau at least two other knolls of basalt, but smaller ones. But these are very few in comparison with the number which may be traced on the westerly declivity of the present platform. As these last, however, are without the limits of the district to which I have confined myself, they may be passed over.

The basalt is unscorified and very hard. It contains minute crystals of pyroxene, together with some little olivine.

## SECTION II.—THE ERUPTIONS OF THE NURBURG.

The Nurburg, upon which the ancient castle, now in ruins, of that name is built, is an insulated cone, the height of which above the Rhine is 2015 Rhenish feet, with a summit chiefly formed by the eruptions that have pierced through strata of argillaceous schist.

The hill exposes to view a heterogeneous mass of volcanic products, cemented together by materials in a state more or less scorified, among which we find masses and fragments of trachyte of different qualities, of mandelstein, and of basalt.

Of these, one of the oldest eruptions appears to have consisted of trachyte.

The base of this trachyte is of a yellowish-brown colour, varying considerably in its shades. It contains, though rather sparingly diffused through it, crystals of glassy felspar about half an inch in length. Minute crystals of hornblende may also be detected in it, together with some little magnetic iron ore. We also find entangled in its substance small fragments of clay-slate.

A second volcanic product to be observed on the Nurburg very much resembles the secondary porphyries of coal formations. The base of this substance is of a deep reddish or umber-brown colour, and it has a compact texture. In some specimens which I collected the porphyritic structure is little discernible; but in others there are innumerable disseminated crystals of a liver-brown colour, some few of which are reduced, apparently by the force of heat, to a half pulverulent state of an ochre-yellow colour. And again, in other portions of the rock an amygdaloidal structure is induced; many minute amygdaloidal cavities being observable in it, which are filled with concretions of chalcedony scarcely larger than millet seed.

Under what particular circumstances these rocks were protruded is not very evident. It is not improbable that something like a crater subsisted in which water acquired a lodgement. This may be inferred from the presence of yellow tufa resulting from felspathose matter, in which numerous fragments of rocks are found confusedly entangled, as well as from the ejected fragments of pumice discoverable of a wax-yellow or yellowish grey colour.

The state of confusion indicated by this congeries of volcanic fragments might have been induced by subsequent and deep-seated eruptions of dikes of basalt, fragments of which are intermingled in the same conglomerated mass.

The internal structure of the basalt, which is thus displayed in fragments only, is rather a peculiar one. It appears to have been formed by an immense congeries of bluish or greyish black particles, having a tendency to assume an angular shape, which is defeated by their intermixture with the substance of their base, of a

lighter shade, by which they are cemented. The lar particles appear to be those parts in which freely as an ingredient, while the lighter cemer presumed to consist the most of felspar. The through the substance of this rock some litti of which vary in their dimensions from the te inch. Owing to this peculiar structure, the fi duced has a rough and uneven surface. The hard one, and from the preponderance of felspar with the looseness of its texture, it is rather prone tion.

In the last place, among the volcanic products of t a more compact basalt is to be found. It is greyish-b compact and hard; and it contains very small imperfec of augite. I could not detect in it any olivine.

### Section III.—The Eruption of the High Acht

The High Acht is not only the highest hill of the distı which our investigations are confined, but it is likewise the est hill of the Eifel, where it is geographically placed. It insulated cone of grauwacke schist, inclosing marine shells, capped with basalt. So wild is the form into which it is torn, so uneven is its westerly escarpment, diversified as it is by i merable protuberances and ridges, that we find ourselves dece in its altitude, which does not exceed 2229 feet above the l of the Rhine at Coblentz, * conceiving ourselves to be gazing u the highest and wildest of the Alpine range.—(*See Plate* 6.)

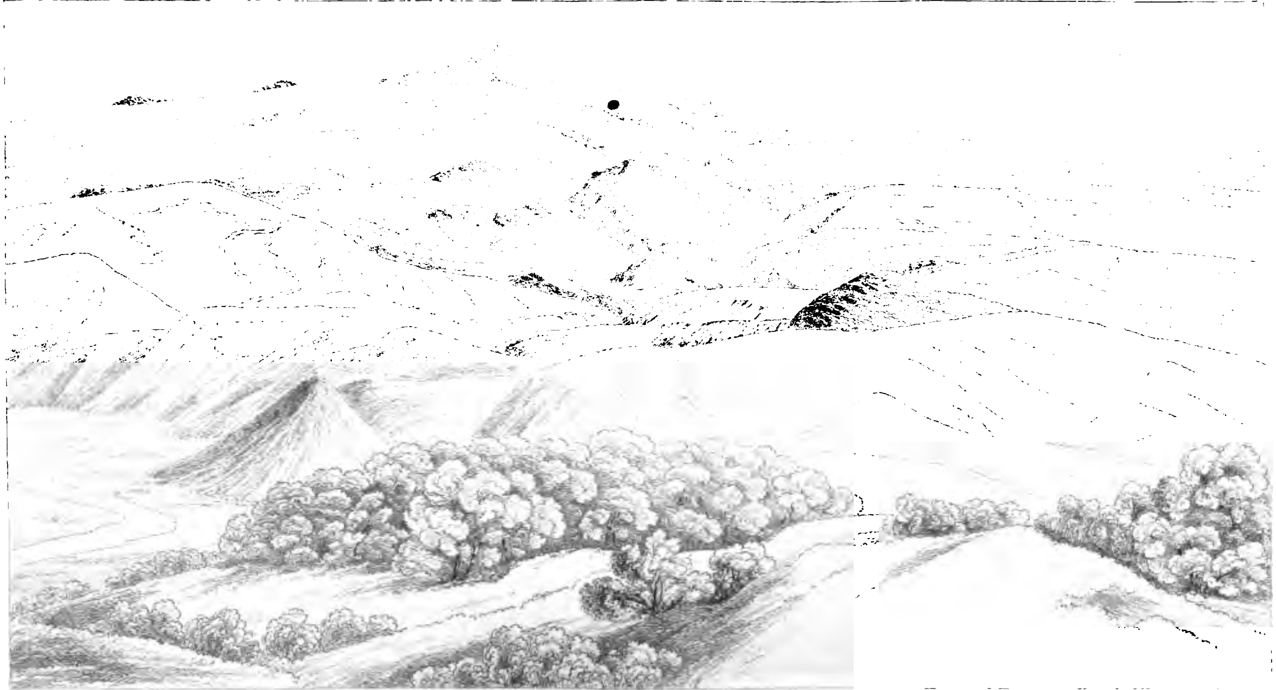
The basalt which appears on this hill is of different variet One of these is like that which is observable in the Nurbu appearing as if composed of an immense congeries of bluish greyish-black particles of a pyroxenic character, and having a t dency to assume an angular shape, which is defeated by their termixture with a cementing base of a lighter shade, that pa takes more of felspar. In this basalt there is perhaps less olivi diffused than in that of the Nurburg.

Another variety of basalt to be found on the High Acht i of the usual greyish colour of this rock; of a very hard consistence, and containing minute particles of olivine very abundantly diffused through it. Crystals of augite are less abundant, prevailing most in those parts where grains of olivine become comparatively rare. Small portions of clay-slate in a semi-scorified state may also be found entangled in the rock. The basalt of the High Acht is highly magnetic, as I found by the disturbance which the compass experienced when placed on the summit of the mountain.

* From the observations of M. Umpfenbach of Coblentz, who has estimated its height at 2434 feet above the level of the sea.

PLATE VI.





Lastly, the rock assumes a beautiful prismatic form; its columns being quarried for various economical purposes to which they are applicable.

SECTION IV.—THE NUMEROUS MINOR ERUPTIONS OF BASALT TO BE DETECTED IN THE VICINITY OF THE HIGH ACHT AND OF VIRNEBERG.

It is a curious feature of this particular district that basaltic eruptions, apparently in the form of dikes, should occur on such a diminutive scale, that their out-breakings are often to be traced with difficulty.

A basaltic knoll, for instance, lying a short distance north-west of the castle of Virneberg, is capped with a protuberance of basalt so trivial, that, although in this locality such a rock has been considered a great desideratum for the construction of roads, its presence, until I pointed it out, had been overlooked.

A similar appearance I also detected on a knoll nearly south-east from the High Acht, or S. 80 W. from the summit of the Langenfeld.

On two hills of grauwacke schist, containing marine shells, situated north by east of the High Acht, and north-west of the Leimbach, which, from their peculiar acute summits, I suspected to be volcanic, I found numerous fragments of basalt that led me to infer, that similar minor eruptions had taken place from these points, but so small as to have been rendered capable of concealment or obliteration by a slight process of levelling for the more ready operations of the plough.

But these are not all the eruptions of basalt which the high lands of this district would exhibit if properly examined, and I lament having had so little time for this purpose, which must necessarily have been a tedious investigation. Between the crater of Boos and the hill of Nurburg, fragments of prismatic basalt appeared strewed over the marshy surface of the ground.

The high hill of the Langenfeld, the height of which has been estimated at 1670 Rhenish feet above the level of the Rhine, appeared to me a site through which it was very probable that some volcanic eruption might have taken place; but I was assured that my suspicion was unfounded, and that the mountain consisted of nothing more than the argillaceous or grauwacke schist of the country. I regret that this locality was the last which I visited, before I was suddenly called away. I had only time to make an attempt to reach the summit of the Langenfeld, during which I was benighted and almost lost in the endless maze of deep defiles and ravines which are laterally connected with the channel of the Nette.

To particularize the different qualities of the basalt occurring

on the various points of eruption recapitulated, can scarcely be expected. I found them to be in general very hard and unscorified, of a blackish-grey colour, and containing minute crystals of pyroxene with very little olivine.

### Section V.—The Crater of Boos.

This crater, which is perhaps of a later date than that of any volcano yet described in the vicinity of the High Acht, is situated to the south-east of the hill of the Nurburg, and near a small village named Boos. The height of the crater above the level of the Rhine has been computed at 1312 Rhenish feet.

The circumstances to be investigated in this volcanic eruption are the crater; and the substances of which the crater walls are composed.

A ground plan of the crater of Boos appears in the general map, which is of the amazing diameter of three quarters of a mile or more. M. Steininger conceives that on this site there is not one but two great crater-formed openings surrounded by lofty walls of slag, tufa, and sand. I am, however, myself inclined to think that the appearance of two half-demolished craters, one within another, is an illusion, having been produced by the falling in on the west and north-west side of a considerable portion of the wall of a single crater, amounting in extent to perhaps a third of the whole.

Whether this supposed subsidence has been produced by the operation of rains or sudden floods acting upon the loose crater walls, or by the still more violent agency of subsequent eruptions of basalt, I am unable to state, as the very covered and often marshy state of the low ground is unfavourable to the examination. Some suspicion of the latter cause is excited by the loose blocks of basalt, generally prismatic, which are found on the north-west side of the crater.

The walls of the crater have in a great measure been formed by the explosive projection of scoriaceous fragments of basalt. These are of a pitch-black or brownish-black colour, and inclose very minute crystals of pyroxene as well as olivine; the latter being in a sparing quantity. But these scoriæ are chiefly remarkable for containing in them innumerable entangled portions of clay-slate of an ash or smoke-grey colour, which have evidently suffered from the action of heat. Their medium size is about the fifth or tenth part of an inch. Frequently, however, we find among the ejected fragments of rapilli and ashes, which contribute to form the crater walls, very considerable fragments of clay-slate, as well as of grauwacke sandstone wherein pectinites are inclosed, together with larger masses of black slag, the surface of which is in a glazed or vitrified state.

## CHAPTER IX.

RETROSPECT OF THE PROGRESSIVE STATE OF THE SAND AND CLAY DEPOSITS OF THE BASINS OF NEUWIED AND COLOGNE, FROM THE PERIOD WHEN ERUPTIONS OF TRACHYTE HAD THEIR COMMENCEMENT.

HAVING at length described the eruptions of trachytic felspar and of earlier basalt incidental to the district which we are examining, we may now conveniently inquire into the contemporary lacustrine deposits which were going on, as well in the lower lake of Cologne, as in the upper one of Neuwied.

It has been remarked, that when the waters of the basin of Neuwied subsisted at their original height, there was in the place of its present gorge a barrier of continuous cliff, to the north of which a deep-fissured channel subsisted, which conveyed its overflowings into the lower fresh-water basin of Cologne. Consequently, under such a state of mutual connection, it becomes difficult to fully explain the deposit of one lake without some degree of reference to that of the other.

The relative situation of this basin may again be conveniently introduced to the reader in a repetition of the sketch illustrative of the tertiary geography of the Lower Rheinland.


The upper fresh water basin, which I have named the Basin of

Neuwied, appears, as I have observed, to have owed its origin to the forces which at distinct points were employed in elevating the nearly parallel ranges of mountains named the Eifel and the Westerwald, to which the depression is intermediate. Originally, the gorge of the basin of Neuwied, situated close to the city of Andernach, did not exist, in the place of which a barrier of continuous cliffs rose to a considerable elevation, not less perhaps than 800 feet above the present level of the Rhine, or 1000 feet above that of the sea. To the north of this barrier the deep-fissured channel of the Rhine was resumed, which conveyed the overflowing of the upper basin into a lower one, which I have named the basin of Cologne. The lake of Neuwied was in extent from sixteen to eighteen miles from east to west, and from four to seven from north to south.

The lower basin of Cologne, which commenced near Linz, and which underwent a considerable expansion near the Siebengebirge, was bounded on the west and east by the clay-slate and sandstone hills of Duren and Westphalia, while its termination may be supposed to have been not far from the present site of Dusseldorf. It is calculated to have been not less than forty English miles long, and from ten to twenty broad.*

The general nature of the formation which, at the commencement of the tertiary epoch, occupied the upper and lower fresh water basins of the Lower Rheinland may be summed up in a few words: It consisted of beds of fine sand, sandstone, and plastic clay.

The origin of this deposit, as I have remarked, (page 19) can scarcely be a mysterious one. It is natural to look for the transportation of it to the rivers by which the basins were fed;—which origin (infinitely the most simple one to comprehend,) is, if possible, rendered more plausible by the indications which the plastic clay, the fine quartzose particles of the sand, and their diffused scales of mica afford, of their having been derived from a primary class of rocks, consisting of such as are the most frequent in the Rheinland, namely, of clay-slate or grauwacke schist, traversed by veins of quartz.

This formation will now be described in detail:

### 1st, *The Beds of Sand.*

The lowest beds display an incoherent SAND,—showing that this was the earliest deposit of the lacustrine waters. It consists, according to the summary of its characters given by Professor

* M. Boué, from his observations on certain marls at the foot of the Harz near Gladbach and the Bansberg, has supposed that the Cologne basin admitted into it the waters of the ocean. That such was its state immediately prior to the elevation of land which gave rise to the brown coal basin of the tertiary epoch, is not improbable. But I am by no means satisfied, for reasons which will be explained hereafter, that, subsequently to this elevation, the basin of Cologne was any thing more than a fresh-water lake.

Noeggerath, of fine, round, clear transparent quartzose grains, generally mixed, though not abundantly, with minute silvery scales of mica. Party-coloured varieties may be also met with. Grains, for instance, of a common yellow colour are sometimes found in abundance, and impart their hue to a large mass;—those of a wine-yellow variety are comparatively scarce. Other tints are indigo-blue, bluish-grey, hyacinth, or flesh-colour,—though these are sparing occurrences.

In the upper lake of Neuwied there are evident indications that this sand formed the chief substance with which it was filled. Traces of it are to be found at Kottenheim, where it appears of a yellowish or milk-white colour; also at Obermendig and other places, where it covers the clay-slate mountains. The crater of Laach, which, as I have shown, was a volcano that broke out on the very margin of the great lacustrine expanse of Neuwied, where it assumed the form of a creek belonging to the lake, soon received within its cavity the light particles of earthy matter which floated through these waters, and soon became the site of a deep fresh water deposit, which covered the previously protruded trachytic rocks. Remains of this upfilling mass are accordingly shown in two patches of stratified sand on the north and north-east sides of the lake, where they line the clay-slate rocks at a height of perhaps forty or fifty feet above the present level of the waters. This deposit consists of remarkably fine grains of sand, generally of a straw-yellow colour.

In the lower fresh water lake of Cologne the same sandy deposit prevails, differing only from that of the basin of Neuwied in its occasional passage into sandstone.

*2dly, The Beds of Sandstone.*

This sandstone, which is only found in a few places, and which, whenever it occurs as the concomitant of the quartzose sand, forms its uppermost bed, has been particularly described by Professor Noeggerath. It differs in the fineness or coarseness of its ingredients; in the nature of its cement; and in its degree of firmness or cohesion.

The structure of the finer variety, which is the most prevalent kind, may be described as granular; the grains being like those of sand which are connected either by a quartzose, a ferruginous, or an argillaceous cement. When the cement is quartzose, which is its predominant character, the cohesion is oftentimes so intimate, that a distinct granular structure is not always distinguishable; the rock having an imperfectly conchoidal and splintery fracture, and approaching to the appearance of hornstone. In other instances, however, the granular particles are so incoherent, that the stone admits of being frittered to pieces with the fingers.—The ce-

ment may also consist of the hydrous oxide of iron, when the sandstone has less of a spotted yellow than of a streaked colour.—And, lastly, strata are found which have an argillaceous as well as ferruginous cement;—whence the yellow and brown tints which they exhibit.

The structure of the coarse variety of sandstone, which is comparatively rare, is best observed in the Siebengebirge. It is distinguished by fragments of coarse quartz and hornstone often an inch in thickness;—the fragments resembling the quality of the finer and firmer sandstone described, the grains of which are connected by a quartzose cement. The colour of these coarse ingredients shows various commixtures and shades of blue, gray, and milk white; less frequently, the blendings of grey, black, brown and yellow; and least of all, those of yellow, green, or rose-red.

When observed *in situ*, it is found nearly horizontally disposed in the form of beds from one to three feet in thickness;—which in the Siebengebirge exhibit fissures that open wedgewise towards the upper surface, and appear like yawning clefts.

This description I shall close by M. Noeggerath's illustration of the general relations of superposition which the sand and sandstone observe, as they are exhibited in a descending series of beds at Liedberg in the circle of Gladbach.

*(a.) Kiesel Gerolle.* This overtopping bed of quartz pebbles mixed with coarse yellow sand to the depth of ten to thirty-five feet, does not at present demand our particular attention. An explanation of its origin will be attempted in a subsequent chapter.

*(b.) Falscherstein.* A very incoherent sandstone, 8 to 10 feet thick, pervaded by thin seams of red or yellow ochre.

*(c.) Haustein.* A firmer sandstone, fit for architectural purposes, of a greyish white colour, with yellowish streaks. Passes gradually into the upper bed.

*(d.) Klinkert.* (quartz-sandstone.) Of uncommon hardness; being only fit for turnpike roads. The fracture splintery and conchoidal.—4 to 5 feet thick.

*b. c. d.* are sandstone beds, conjointly $2\frac{1}{2}$ to 3 fathoms thick, with an inclination from 4° to 5°.

*(e.)* A beautiful fine, white, quartzose sand. Seven feet of the sand have been opened. The depth is unknown.

*3dly, The Plastic Clay.*

A third substance, found alike in the basin of Neuwied and Cologne in the form of beds, is plastic clay.

This substance may be regarded as a commixture of the finer particles of silex, alumina, and even other earthy ingredients, with the addition of iron, and, perhaps, manganese. It is also observ-

ed to pass into sand, similar to that which I have described as consisting of quartzose grains and minute scales of mica. The colours which it displays are various; the most common being milk-white, or yellowish. At Mayen, crimson-red variegations are exhibited.

Concerning the origin of the plastic clay there is perhaps some little difficulty. The disintegrated materials brought down by the Rhine, the Moselle, and other streams, having been diffused through a great expanse of waters, grains of quartz would, from their gravity, be the first precipitated; while this precipitation would be the greatest in the depressions nearest to the mouths of these rivers. But more levigated particles, of a siliceous as well as of an argillaceous character, would remain longer suspended in the superambient fluid, and would therefore be borne by currents to considerable distances, and dispersed through the body of the great lacustrine waters. Hence, probably, the thick bed of fine clay which has been traced so far as Holland.

In such particular lacustrine sites, however, as have not been exposed to the direct force of currents, much argillaceous matter remaining suspended would tranquilly subside, and form the beds covering substances before accumulated, or even, as we find at Mayen, in the vicinity of Coblentz, constituting an independent local deposit of plastic clay.

The localities in which plastic clay is met with are numerous, and, owing to the great demand for this substance as an article of commerce, have been sufficiently well explored. In the upper lake of Neuwied, clay-pits have been dug at Dreckenich, a league from Gondorf, (whence great quantities of plastic clay are exported,) at Bannerhof, Kruft, Frauenkirk, Ettringen, Mesenheim near Andernach, and the Lake of Laach. At the latter place plastic clay, some of it of a peach-red colour, may be observed in some places to repose upon the sand.

In the lower basin of Cologne there is also much plastic clay, but less pure. It is found near the Siebengebirge of a yellow colour, and in various other sites.

### *4thly, The Vegetable remains contained in the Sand, Sandstone, or Plastic Clay.*

The inferior beds of the lacustrine deposit of the Lower Rheinland have at length been shown to consist of beds of sand, surmounted, in a few places only, by a newer sandstone, or by more abundant beds of plastic clay.

That during this deposit a vegetable creation subsisted, we have some few indications. Among the lower beds of sand there are occasionally disclosed certain blackish or brownish particles associated with quartzose grains slightly attrited, which have been

judged to be carbonaceous, or, in other words, to have the character of brown coal.

In the sandstone also vegetable remains have met with conservation. The Siebengebirge beds inclose pieces of wood-opal and semi-opal a foot or more in extent, which often contain in their clefts coatings of stalactitic milk-white chalcedony. The silicified wood which I obtained from this site resembled the internal structure of the coniferous tribe. Other specimens which I procured had well-marked impressions upon them of leaves. Such impressions are generally covered over by a yellow hydrous oxide of iron.

That any large animals lived during this deposit of sand, sandstone, and plastic clay, we have no evident proof whatever to show. The scanty vegetation which then subsisted scarcely encourages such an expectation. Professor Noeggerath, in a memoir published by him, (*Das Gebirge in Rheinland Westphalen, &c.* Vol. iv. p. 375,) has stated, that on the surface of the lower bed of sand, in a section of the quarry of Liedberg, the bones of extinct animals were found. But I have lately been informed that this statement, which was originally published on the fallible authority of workmen, has been found incorrect.*

Such is the evidence of the scanty vegetation subsisting during the dawn of the tertiary epoch, which the deposit of the ancient lake of Neuwied likewise confirms. The lignites which at Kreutzkirk and elsewhere form the upper beds of the plastic clay, belong to a somewhat later period, to be described in the ensuing chapter.

In short, it may be generally remarked, that it is at least presumptive, that the west of Europe then enjoyed a temperature so far exceeding that which at present prevails, as to render it the region of Palms. This is to be inferred from the numerous arborescent monocotyledons found in beds of rather a later date belonging to the lower basin of Cologne. In the higher lands of Europe it is probable that a different vegetation subsisted, and that to the drifting which had then commenced of the coniferæ of Alpine heights, the silicified wood found in the sandstone of the Siebengebirge may be referred.

5. *The Volcanic Eruptions contemporary with the sand, sandstone, and plastic clay of Neuwied and Cologne.*

Either immediately previous to, or contemporary with the very commencement of the formation which I have described, was the volcanic eruption of the Laacher see, the crater of which was filled, as I have shown, with a deposit of sand and plastic clay.

* I gave additional publicity to the error first promulgated by the Professor of Bonn, in a memoir on the Brown Coal Formation, which I published in a late Number of Dr Brewster's Journal; but I have been since apprized of the mistake by Professor Lyell.

All the other trachytic volcanos which I have described are referable to a more advanced stage of this process of deposition. This is shown in the lower fresh water basin of Cologne, where it would appear, that the sandstone of Queggstein in the Siebengebirge lies beneath strata of tufaceous mud, (named by German geologists Trachyte Conglomerate,) indicating that the formation of the latter took place at the close of the sandstone deposit of the Lower Rheinland.

## CHAPTER X.

RETROSPECT OF THE DEPOSITS OF BROWN COAL, WHICH, DURING THE ERUPTIONS OF TRACHYTE AND EARLIER BASALT, EXPLAINED IN THE FOREGOING CHAPTERS, REPLACED SOME OF THE FRESH WATER BEDS OF AN EARLIER TERTIARY DATE.

In the present chapter I propose to continue my researches in reference to the brown coal, which imparts its name to the whole of its associated beds. At the same time it may be added, that no tertiary deposit in Europe is perhaps, in its various relations, more difficult to explain. As almost every writer who has taken up his pen in this inquiry has differed from his predecessor in the views which he has adopted of its relative age, it will be easily imagined that I have imposed upon myself a task of no little intricacy. This is indeed my own persuasion, and I have entered upon the investigation with a corresponding diffidence.

Nor ought I to omit mentioning, that in this research I have availed myself of the information supplied by various writers. Many details have been furnished by Professor Noeggerath of Bonn, who, in his office of superintendant of the mines of that district, has become familiar with all the localities of the brown coal formation. Other incidental notices regarding it are to be found in the works of Professor Steininger of Treves, and in the system of geology published by Professor Leonhard of Heidelberg. As the labours of these several writers are much less known in this country than they ought to be, I gladly avail myself of any opportunity afforded me to communicate the valuable information which they have imparted, where my own observations may have proved deficient.

Preparatory to the ensuing description of these brown coal beds, may be noticed the increase of vegetation which took place at the close of the deposits of sand and clay described in the foregoing chapter.

At this time, the climate of the Lower Rheinland must have gradually cooled, so as to approach that of the temperate regions of the globe. This may be inferred from the proofs which are afforded that the oak, the beech, and other forest trees of less warm climates, were once contemporaneous with the fossil palms of Cologne, which they far exceeded in abundance;—a circumstance which renders it highly probable that the temperature of this district nearly resembled that of the southern coasts of Italy, or of Spain, which can still tolerate the growth of plants of opposite regions. Thus, at S. Remo, in the Genoese States, dense plantations of palms had long subsisted, which were latterly encouraged for the sake of the branches required for the papal processions of Palm Sunday. And at Murcia, the palms which many ages ago had been particularly noticed by Pliny, continued to be fostered for the sake of a similar pious traffic with Italy, so late as the year 1775. "We stopped at Elche," says the intelligent Swinburne, "a large town belonging to the Duke of Arcos, built on the skirts of a wood, or rather forest, of palm-trees, where the dates hanging on all sides in clusters of an orange-colour, and the men swinging on bass ropes to gather them, formed a very curious and agreeable scene. *The palms are old and lofty; their number is said to exceed two hundred thousand.* Many of the trees have their branches bound up to a point, and covered with mats, to prevent the sun and wind from getting to them."

In the higher lands, however, from which the Rhine derived its origin, there is every reason to suppose, as I shall very soon show, that a perfectly different vegetation, corresponding to a colder climate, now began to subsist. The description of trees which flourished, comprised the *Pinus picea*, or the *Pinus abies*, the beech, the oak, or the alder. With these, the common heath *(Erica vulgaris)* was contemporary.

It is also a circumstance of no little interest, that the brown coal deposit furnishes us with a date when certain large animals were called into existence, which ranged among the ancient forests and swamps of Europe, before its soil was adapted to the residence of man. But regarding the particular races which during this period existed in the Lower Rheinland, we are scarcely yet furnished with authentic details. Faujas St Fond, on the authority of a miner, mentions, that in the earthy brown coal of Brühl and Lieblar the remains of a cervus have been found.

After this general explanation, I propose to consider the action of the currents incidental to the tertiary epoch, in their removal of the vegetation which has given rise to beds of brown coal.

The remark of M. Boué has been before quoted (p. 17), that, owing to the difference of climate during the tertiary epoch, the

waters poured upon the earth must have been so immense, that the debacles of modern lakes and the excavations of equatorial rivers can convey but a faint idea of their effects. In supposing, then, that such inundations must at various intervals have imparted an influence most destructive to the rapid currents of the Lower Rheinland, it is evident that there would ensue considerable removals of the beds already deposited in the lakes of Neuwied and Cologne, and that this disturbing cause would more particularly affect the upper strata. Thus, at Roisdorf, loose blocks only remain of the continuous bed of sandstone which reposed upon the sand, and, at Friersdorf, no trace whatever of the same has been left. Nay, in some places, the waste appears to have extended to a much greater depth ; removing the subjacent sand altogether.

The immense beds of sand or sandstone thus carried away by corroding streams, were in some few sites replaced by other depositions. During the retiring of the waters, limited basins were in many places formed, favourable to the production of lesser lakes or pools, and being filled with waters in which lighter matters were suspended, various local deposits became the result.

The proof that the vegetation of the Lower Rheinland must have flourished most during this succession of changes, is, that the lowest brown coal beds or lignites in the neighbourhood of Cologne may be seen to rest upon the loose sand from which the sandstone has either been removed altogether, or appears in the form of severed or insulated blocks. This is shown at Roisdorf, where, upon the loose sand from which the sandstone has been removed, rests bituminous clay ; or at Bruhl, where, under similar circumstances, repose powerful clay and brown coal beds.

Owing to this association of beds of sand, sandstone, plastic clay, and lignites, the same are conjointly known by the name of THE BROWN COAL FORMATION ; under which title they will in future be distinguished.

The formation of brown coal, including its associated beds, may with various interruptions be traced from the basin of Andernach along the course of the Lower Rhine, where it occurs on both sides of the river, particularly near the Siebengebirge, covering the declivities of the schistose mountains. Along the ridge of hills which extends from Godesberg to Bergheim, it forms deep beds, and is then lost in the flat ground of the lower lands.

These very general circumstances being premised, I shall proceed to explain in order, 1*st*, the deposit of brown coal in the lower lake of Cologne, which replaced the removed beds of an older date ; 2*dly*, the similar deposit of brown coal which took place in the upper lake of Neuwied ; and, 3*dly*, the volcanic eruptions which were contemporaneous with the brown coal beds.

SECTION I.—THE DEPOSIT OF BROWN COAL IN THE LOWER LAKE OF COLOGNE, WHICH REPLACED THE REMOVED BEDS OF AN OLDER DATE.

There is reason to suppose, that, at this period, while numerous forest trees, such as the oak, the beech, or the pine, began to occupy the firmer shores which were slowly laid bare, sandy or mud-formed tongues of land and islets were developed, in the soft materials of which palms fixed their roots, along with an abundance of aquatic reeds or sedges, the debris of which may be traced in the thick existing beds of earthy brown coal.

During adventitious periods of inundation, the vegetation which had thus taken root would be liable to be submerged beneath the materials of the sandy or loamy beds which had been removed; and, more particularly, beneath the beds of plastic clay, which, in forming the upper layers of the lacustrine deposits of the Rhine, would be the first disturbed;—while accumulations of drift-wood, transported by the rush of inundations, and covered over by renewed earthy deposits, would induce the frequent alternations of clay and brown coal beds, which are so observable in the district of the Lower Rheinland.

Two examples of these alternations, on the authority of Professor Steininger, may be quoted, the beds of which are given in a descending series.

| AT FRIESDORF. | AT WALWERBERG, LIEBLAR, AND BRUHL. |
|---|---|
| Gerölle, (gravel,) | Gerölle, (gravel,) |
| Brown coal, | Brown coal; 26 to 32 feet thick, |
| Potters' clay, | Potters' clay; unknown depth. |
| New brown coal floetz; not worked through at 20 feet. | |

But these are not all the circumstances to be kept in view. A question is suggested, Why the remains of Coniferæ, of the beech, the oak, or the elder, are so much more abundant in the brown coal beds, than those of arborescent monocotyledons?

This question may perhaps meet with the following solution:

Much of the vegetable matter, indicative of temperate rather than of tropical regions, must have been brought down by the Rhine during periodical or occasional floods, from more elevated lands, where the temperature must have differed greatly from that of the low declivities of the Rheinland; having been deposited while the lacustrine waters maintained their high level, after the manner of the immense accumulation of drift-wood incidental to the embouchures of the great rivers of North America, which has been transported from the region of the pine to that of the fig or the olive.

This view will be confirmed by the circumstances under which many of the fibrous or ligneous brown coal beds are found; while, on the other hand, some trees have been disinterred, consisting of palms as well as oaks, which show that they must have flourished simultaneously. Thus, at Lieblar, near Cologne, a palm was found in an erect position, and, under similar circumstances, the dicotyledonous plants of temperate regions have been discovered.

We must conclude, then, that the same floods which, from remote elevations, differing considerably in temperature, would transport the spoils of overgrown woodlands, would also undermine the densely planted margins of contiguous embouchures;—or, that the swollen Rhine, in its impetuous course, would sweep away the foundations of much adjacent soil, causing land-slips, or even bearing with it numerous floating islands, with multifarious trees still clinging in an erect posture to their native soil; and that these, when their further progress was resisted by shoals or any other impeding cause, would be mingled with the far imported drift-wood of alpine heights.

A theory of this kind would meet with some support, if it could be shown that trees occur mingled indiscriminately in the same bed in both a vertical and horizontal position; the former indicative of a growth *in situ*, and the latter of distant transportation.

An observation to this effect has, indeed, been already made. Professor Noeggerath has recorded, that at the Pützberg, near Friesdorf, the upper beds consist of variously alternating beds of earthy brown coal, bituminous wood, alum earth, and potter's clay, in which are found isolated trunks of trees, some of them resembling the oak, of enormous thickness, varying from seven even to twelve feet in diameter, and destitute of their upper parts, which appear as if broken off or split. While some of these trees are horizontally imbedded, others are found standing upright, and passing through all or most of the associated beds of brown coal, alum earth, or potters' clay.

But there are still other effects which would result during this process.

Much of the surface of the sandy or argillaceous deposits, which in their removal had been left exposed, would present concavities of greater or less depth, which would be filled with the waters which remained upon the occasion of their emergence. Into these minor lakes or pools, generally formed by depressions made in the upper strata of plastic clay or brown coal, the disintegrated materials, derived from the gradual waste of adjoining hills of primary schistose strata, appear to have been washed; and these, mingling more or less with the bituminous matter of brown coal beds, or coexisting vegetation, or with the earthy particles previously suspend-

ed in the waters of these small basins, appear to have given rise to corresponding strata, which are to be regarded as little more than varieties of common shale, generally bituminous.

German geologists have, however, subjected these strata to very forced distinctions, as into (*a.*) *Klebschiefer*, adhesive slate ; (*b.*) *Polierschiefer*, polishing slate or Tripoli ; and (*c*) *Papierkohle*, paper coal.

(*a.*) *Klebschiefer*, Adhesive slate, so named from adhering to the lip when moist, has been described as of a light yellowish grey, greyish white or smoke-grey colour, thin and slaty in its texture, and in its fracture flatly conchoidal; easily triturated, and shivering readily in the direction of its laminæ. Menilite is sometimes inclosed by it in small roundish and flattish nodules. The analysis given of adhesive slate is so various that it is not worth stating. It must necessarily differ in different places, according to the ultimate nature of the substances from which, as a shale, it is derived.

(*b.*) *Polierschiefer*, Polishing slate or Tripoli.—I cannot find that this substance differs materially from adhesive slate. It is described as of a yellowish or reddish white colour, easily separable into thin and slaty laminæ, which are so tender that they may be rubbed to a powder by the fingers. The notion of its having assumed this condition from the operation of fire, is not on the present occasion to be entertained; the effect being more like that of dryness or weathering.

Both the adhesive and polishing slate are described as absorbing water with avidity, and throwing out air-bubbles.

(*c.*) *Papierkohle*,—Paper coal.—This is of a blackish brown colour, with a dull, as well as glistening lustre; divisible into uncommonly thin and tender leaves, whence its name of paper-coal.

All these three substances, viz. adhesive slate, polishing slate, and paper-coal, pass into each other.

Such is the character of the strata which form the beds incidental to the pristine pools in which they were deposited. While the process was going on, these basins were stored with numerous fish, frogs and lizards, of species still existing, which are now discovered interposed and flattened between the folia of the shale which I have described. In a quarry near Unkel, I was so fortunate as to obtain the impression of an insect about the size of a common bee, and resembling an individual of the Hymenopterous, or perhaps Dipterous order.

Plentiful impressions of leaves and trees also appear under similar circumstances, which, as well as the beds of brown coal associated with the shale, seem of an extraordinary freshness; having been apparently derived from the later plants which flourished around the margins of these pools.

This account of the associated shale and brown coal beds, meets with a good illustration in the following section of a pit near the Siebengebirge, from the surveys of continental geologists. The beds are stated in a descending series:

Loamy soil containing brown coal.

Loam strata.

Brown coal, consisting of the carbonized wood of trees.

Shale (Adhesive and Polishing slate;) containing impressions of fresh-water fish and plants.

Paper coal, with impressions of fish and plants.

Greyish-white potters' clay; the lowest observed bed.

The general circumstances connected with the deposit of the brown coal beds have at length been described.

The thickness of these beds is various. One German author has affirmed that they do not exceed 6 or 8 feet; while another, who appears more familiarly acquainted with them, mentions beds 18, 24, 26, or even 32 feet thick.

Lastly, with the aid of the excellent account of the brown coal beds which has been published by Professor Von Leonhard, we may glance at their different mineralogical characters.

This distinguished naturalist divides brown coal into (*a.*) pitch coal, or jet; (*b.*) common brown coal; (*c.*) bituminous wood or fibrous brown coal; (*d.*) moor coal; (*e.*) earthy brown coal; (*f.*) alum earth.

(*a.*) Of *Pitch-coal, or jet*, I shall say little, as its character is well known. It only appears in small layers or nests in the common brown coal.

(*b.*) *The common brown coal*, which is the predominating species, appears in beds of great thickness and extent, and is chiefly distinguished by the form of wood being only in part recognizable, by the texture being only occasionally fibrous, or by the complete absence in it of the well known fibrous structure of wood. Its specific gravity is 1.28. It is blackish brown and compact. Its fracture is earthy, and approaching to the conchoidal, and it has a greasy lustre. In burning, it first gives out a little smoke, but afterwards brightens up with a tolerably pure flame, yielding an ash very like that of wood, but more earthy, and containing, somewhat plentifully, iron and potash. It yields from 45 to 50 per cent. of carbon and earthy materials, and 55 of volatile matter; leaving, after being consumed, from six to eighteen parts of a residue.

(*c.*) *Bituminous Wood, or Fibrous Brown Coal.*—This substance marks the first degree of change from an organic to an inorganic substance, in which the history of brown coal is to be read.

It is of a blackish brown colour, showing distinct fibres of wood. The bark and annual rings are not unfrequently distinguishable. The stem, branches, or pieces of the roots are in general flatly pressed. The plants to which these remains are referable have been already noticed. Beech, oak, the fir cones of the *Pinus picea*, and more rarely of the *Pinus abies*, also Sumach, (Schwartzholz) and birch. There is also often found in the same bed with the lignites, innumerable seeds of the *Erica vulgaris*, and even the remains of earth-beetles.

The bituminous wood is susceptible of some few modifications. At the Püzberg near Friesdorf it contains a more or less plentiful diffusion of particles of clay ironstone, and, in the same place, a substance like leafy anthracite appears in dark coloured layers. It has also been found, though elsewhere, penetrated by sulphur.

(*d.*) *Moor-coal, (Moorkohle.)* Specific gravity 1.2 to 1.3; colour between pitch-black and blackish-brown; compact; fracture even; lustre dull or glimmering. This substance has been considered as a decomposed brown coal without any ligneous structure. But its character is best recognized by regarding it as composed of reeds and swampy plants.

(*e.*) *Earthy Brown Coal.*—This has been described as nothing more than a common brown coal, decomposed to a higher degree than moor-coal; to which belongs the Cologne umber, or Cologne earth. It has also been regarded as a bituminous substance consisting of destroyed vegetables, such as seeds, and leaves, and stalks of swamp-plants, and rinds of the branches of trees.

The earthy brown coal is remarkable for containing the trunks or stems of bituminous wood, and, according to M. Faujas, the remains of Cervi and other animals.

Both the moor and earthy brown coal occur in beds of great thickness and extent, only yielding in this respect to the common brown coal.

(*f.*) *Alum Earth (Alaunerde.)*—This is nothing more than a clay, (rich in the alum which it yields,) through which much bituminous matter is diffused. Or, rather, it is a clay with which vegetable matters have been mixed.

German geologists have also enumerated other varieties of brown coal, as the *Bast-coal*, consisting of the twisted rinds of pines and alders, and the *needle-coal*, so named from the needle-like forms, which, in its caprice of structure, it occasionally assumes. But as it is doubtful if these exist in the Lower Rheinland, and as the distinction is at best a subordinate one, I shall pass them over.

Finally, regarding the plants of tropical regions found in the brown coal beds, geologists have at various times supplied us with a list of such as have been entombed, to many of which it has been found rather difficult to assign a correct place in the vegetable kingdom. The list of them which I have collected is as follows:

*Cocos Faujasii*, found at Lieblar in the Cologne district; *Carpolithes Arecæformis*, *C. cocoiformis*, Cologne district; *C. amygdalæformis*, *C. pisiformis*, *C. pomarius*, *C. lenticularis*, Osberg, not far from Erpel; *Endogenites ? bacillaris*, Cologne district.

### SECTION II.—THE DEPOSIT OF BROWN COAL WHICH TOOK PLACE IN THE UPPER FRESH WATER BASIN OF NEUWIED.

The general relations of the brown coal beds of the upper lake of Neuwied would be imperfectly understood, were it not for the ample details afforded by those of the lower lake of Cologne. In the case of the former, beds of sand and plastic clay are sufficiently well developed, while those of brown coal are far less numerous. Alum earth is observable at Kreutzkirk, which, as I have explained, is nothing more than a clay, (rich in the alum yielded by it,) with which the bituminous matter of vegetables is intermixed. That which I examined at Kreutzkirk was of a bluish, or of a brownish colour. Brown coal is also said to be obtained at Emmendorf and at Ehrenbreitstein. I have also been lately apprized that in a valley north of the Perlenkopf, and running parallel with the Brühl, a bed of lignite 1½ toise in thickness has been observed. Near Kempenich I found some fragments of paper coal, the relation of which I could not discover.

Regarding the circumstances under which this deposit of brown coal took place, little need be said after the ample explanation which has been given of the origin of the lignites of Cologne.

### SECTION III.—THE VOLCANIC ERUPTIONS WHICH WERE CONTEMPORANEOUS WITH BROWN COAL BEDS.

With the exception of the very early volcano of Laach, all the trachytic eruptions and craters which have been described, as well as the tufaceous mud which has been accumulated within such trachytic basins, (examples of these being afforded in the volcanos of Rieden, Fusel, Wehr, and others,) appear to have taken place at the commencement of the brown coal deposit. But it ought to be added, that this inference is rather to be collected from observations made in the basin of Cologne than in that of Neuwied. Thus, at the Ofenkulerberg, beds of trachyte conglomerate contain a layer of altered leaves and other remains of plants; and at the Langenberge, altered wood may be found under similar circumstances. At Geistinger, where twelve or more thin layers of sphærosiderite * are alternated with clayey beds, chiefly derived from

* The formation of layers of sphærosiderite is rather an interesting one. Professor Noeggerath has remarked, that although spherical and kidney-shaped nodules of sphærosiderite or carbonate of iron, from an inch to a foot in diameter, have been found in an isolated form in most of the clay beds of the brown coal formation, whole beds of this ironstone have not before been described,

The colour of the sphærosiderite is yellowish grey. It is compact, and of

decomposed trachyte, the whole is surmounted by slaty brown coal and paper coal; the latter containing impressions of leaves and of fish.—(See *Noeggerath's Rheinland Westphalien*, Vol. iv. p. 383, &c. and *Steininger's Memoirs, for farther details.*)

The earlier eruptions of basalt which took place in the Rhine district appear to have been contemporary with the upper rather than with the lower beds of brown coal; for at Utweiler a flow rests upon the same, the substance of which has been converted into a sort of pitch-coal or jet. To this period may be also referred the basalts of Rieden, of the Nurburgh, of the High Acht, and others, with perhaps the exception of the basalt slags of the crater of Boos, which may be of a still later date.

## CHAPTER XI.

### THE ELEVATION WHICH, AT THE CLOSE OF THE BROWN COAL DEPOSIT, CERTAIN MOUNTAINS OF THE LOWER RHEINLAND UNDERWENT.

The period is at length arrived when the associated beds of sand, sandstone, plastic clay, and lignites, which have been described, had attained their greatest thickness.

At this crisis some extraordinary convulsion appears to have taken place, by which the Lower Rheinland underwent some little alteration in its level. Whether this event was coincident with a distant and more extended paroxysm which the rocks of Europe sustained, such, for instance, as that which is referred by M. Elie de Beaumont to his tenth system of elevation, or that of the islands of Corsica and Sardinia, in which he has supposed that the Vosges and the Hundsruck might have participated, remains yet to be determined.

In the Lower Rheinland, evidence is afforded of some slighter elevation which the chains of the Hundsruck, the Taunus, and the Eifel experienced; but that this convulsion may be traced

a flat conchoidal fracture, of a dull aspect, and having a specific gravity of 3.568. When fresh quarried, it shows faint coloured stripes or streaks parallel to the stratification, but which, by the action of the air, come sharply out, and acquire a reddish brown hue, giving the beds a banded appearance like that of ribband jasper. The analysis is carbonic acid, 32.231; oxydulated iron, 52.128; siliceous earth, 5.676; argillaceous, magnesian, and calcareous matters with vegetable remains, 9.965. Total 100 parts.

Near the Siebengebirge, from 11 to 13 beds of this substance, from a few inches to about a foot in thickness, have been worked. They are alternated with strata of clay as well as of volcanic tufa.

to any grander operation which affected the countries of Europe, we are at present only permitted to conjecture.

The elevation of the chains of the Hundsruck, the Taunus, and the Eifel, which then afforded the chief sources to the streams that originally fed the lakes of Neuwied and Cologne, is to be inferred from two traceable events:—The first of these is the accumulation of loose pebbles which covered the lacustrine deposits of the Lower Rheinland, while the second, a subsequent one, is the drainage that ensued of its fresh water lakes.

In the present chapter, I shall confine myself to an investigation of the first of these effects.

### The accumulation of loose Pebbles surmounting the lacustrine deposits of the Lower Rheinland.

The effects which would arise from even a slight elevation of the high land, whence the lakes of the Lower Rhine, previous to the opening of the Loch of Bingen, drew their great sources of supply, is sufficiently evident. Subsidiary streams, now flowing down more inclined channels, would sweep before them with resistless impetuosity all loose and detached pebbles or boulders, which, being eventually collected in the common channels of the Rhine and the Moselle, would be strewed over the lacustrine deposits of the lakes of Neuwied and Cologne, forming an upper bed.

These general circumstances being premised, we are directed by them to investigate such accumulations of erratic pebbles and boulders as may be found overtopping the lacustrine deposits of the Lower Rheinland.

A loose pebbly bed, named Kiesel Gerolle, which only in certain places may be observed to surmount the sand or sandstone, has hitherto met with little attention by German geologists, probably owing to its obscure relations.

The origin of the quartz, of which this pebbly mass is composed, cannot be very difficult to discover. The extensive district whence it is derived consists of clay-slate, traversed in some places very extensively by veins of quartz.* Their accumulation, however, in a rounded form, to the exclusion of rolled fragments of clay-slate or gneiss, may not be so easy of explanation. I would, however, attempt it after the following manner:—

It has been shown, that after fragments of clay-slate or gneiss had been detached by the action of waters, the proneness of their

* Thus, on the south of the Moselle, veins of quartz are very numerous. M. Steininger speaks of three beds as each amounting to a fathom in thickness. At Wiesbaden, according to the same author, gneiss is traversed by quartz; and at Drees, south-west of Wittlich, a large contained mass is recognized by the name of the Frau Wertelstein. In the district from Coblenz to Bingen there is much hornfel in the rock,—a substance nearly allied to quartz.

materials to decomposition would render the substance of them liable to a speedy process of disintegration. Very different, however, would be the fate of detached portions of quartz, which, from their chemical nature, would be enabled to resist the decomposition, which is assiduously dooming to comminution and distant transportation the matrix of clay-slate or gneiss from which they might have been detached. Accordingly, as fragments of quartz incur little loss of substance except from attrition, the amount of rounded pebbles of this rock with which the surface of any district might have been strewed over, necessarily becomes the most faithful chronometer of the great antiquity of its unremitting waste. These rolled and worn down fragments have survived a disintegrating process capable of reducing the argillaceous schist they once traversed in the form of veins to the comminuted state of sand and clay, whence we can readily understand, how to a certain extent the lighter suspended matters with which rivers are fraught, would become diffused through the wide expanse of the basins through which they flowed, while larger pebbles or boulders would not travel far from the course of these streams, but would remain to indicate their ancient route.

These principles are illustrated in an ancient pebbly bed of Kiesel Gerölle observable in the basin of Neuwied, which is of interest in showing the altitude to which the deposit brought down by the Moselle had attained, when the lacustrine waters into which they flowed were maintaining their high level. Thus, for instance, high up the hill of the Carmelenberg, below the outjutting volcanic peak with which it is capped, there is displayed a bed of Kiesel Gerölle, or attrited fragments of quartz of a fine white colour, and coated over by a ferruginous clay. Judging from this, as well as from other elevations which the lacustrine deposit of Neuwied displays, there is evidence that the waters of this upper lake had attained a height of nearly 800 feet above the present level of the Rhine at Coblenz, or of 1000 feet above the level of the sea.

These rolled fragments had been evidently transported by the streams of the Moselle which had emptied themselves into the lake of Neuwied, having been deposited at the embouchure of the river, where the force of transporting torrents would begin to meet with resistance from opposing currents referable to the confluence of the rival stream of the Rhine, and to be consequently divested of much of their force. But as they would continue to be exposed to the abrading action of the Moselle, they would still undergo a diminution of size, though a more gradual one, which would continue until much of their substance had disappeared, or had been diffused through lacustrine waters. At length, however, as a drainage of the lake appears to have ensued, this accumulation of pebbles

would be left as a permanent memorial of the commencing decrease of level sustained by the waters.

Similar beds of Kiesel Gerölle have been likewise observed in the lower basin of Cologne, where they have been probably deposited under similar circumstances. It does not, however, appear that they are found at the same elevation as at the upper lake of Neuwied. They are said to occur upon the Petersberg, one of the Siebengebirge groupe, and on both sides of the Rhine. But it is stated that this deposit does not exceed the height of 600 feet.

At Liedberg, in the circle of Gladbach, an interesting assemblage of quartz pebbles is observable, which at a much lower level surmounts a series of beds of sand and sandstone; the hill being said to rise to no more than 120 to 130 feet above the level of the surrounding plain.

This series of beds is particularly important, in showing the general relations of the sand and sandstone, having been noticed on a former occasion, (see page 78.) The surmounting bed of Kiesel Gerölle is described by M. Noeggerath, as mixed with coarse yellow sand, and at the foot of the hill with loam. Its depth is stated at 10 to 35 feet.

But this remarkable accumulation of quartz pebbles, the size of which appears to have been often diminished in proportion to the distance of their transportation, has met with the most detailed description by M. Faujas St Fond. In his observations on a bed of brown coal, thirty feet thick or more, occurring at Brühl, near Bonn, he states, that it was covered with a bed, twelve feet in medium thickness, consisting of rounded quartz pebbles, the largest of which were but of the size of an egg. He describes the pebbles as being variously white, opaque, or even of a tarnished grey or yellow colour; that they contained among them large brown or reddish jaspers, some of which were coloured as with lees of wine; and that intermingled with these pebbles was some little sand and clay.

In Lieblar, the same geologist found a bed of nearly a similar character, containing pebbles of quartz of a milky-white or greyish-white colour, with common jaspers, among which were confusedly interspersed, though in sparing quantity, fragments weighing from 60 to 80 lbs. but which equally had their worn and rounded angles.—(*Museum d'Histoire Naturelle*, i. 456, &c.)

'Such were the effects of the convulsion which elevated the Hundsruck, the Taunus, and the Eifel. Subsidiary streams, in flowing down channels of increased inclination, must have swept before them all loose and detached pebbles or boulders. The debris was eventually collected in the common channels of the Rhine and the Moselle, and was strewed over the deposits of the lakes of Neuwied and Cologne.

## CHAPTER XII.

THE VOLCANOS OF THE BASIN OF NEUWIED WHICH HAD THEIR DATE ABOUT THE TIME WHEN CERTAIN MOUNTAINS OF THE LOWER RHEINLAND WERE UNDERGOING A SLIGHT ELEVATION.

In the history of the extraordinary geological changes which the basin of Neuwied, in common with that of Cologne, has experienced, we have at length arrived at a period which must be regarded as approaching the close of the tertiary epoch. This period, marked by the incipient drainage of the Rhenish lakes, is most probably that which identifies itself with the date of such tertiary formations as M. de Beaumont has included in his later series. Of these, are such deposits as in the north of Europe are familiar to most geologists under the names of the Grès de Fontainebleau, the upper fresh water formations of Paris and the Isle of Wight, or the Fahluns of Touraine.

Many igneous eruptions in the basin of Neuwied demand investigation, which identify themselves with this more recent period, when, owing to the incipient and progressive drainage which the lake was undergoing, submerged deposits producing beds of brown coal had entirely ceased. This diminution in the level of the waters of the basin of Neuwied, occasioned by the gradual wearing down of the barrier of Andernach, will be rendered manifest when we treat of the volcanos which have appeared upon its margin.

Keeping then carefully in view the very accurate chronometer afforded by the varying state of drainage displayed by the basin of Neuwied, we may now proceed to investigate volcanic eruptions of a later period. But, as it will be impossible during this inquiry to assign in every instance to a volcano a comparative age, I shall, for the sake of greater convenience, groupe together such eruptions as are entitled to be associated, as well for their nearly contemporaneous date, as for their mutual state of local contiguity.

In the volcanos which follow, we shall find that trachytic eruptions had ceased; and that the later basalts which were ejected have, with few exceptions, differed from those of a prior period in the less compact, or in the scorified and cellular aspect which they have assumed. This fact, indicative of the greater intensity or longer continuance of volcanic heat, points to a process which may be still going on in the unknown and deep laboratory of the focus of internal fires.

The loose matter ejected is variously composed of basaltic

blocks;—or of portions of primary rocks torn from the walls of volcanic vents;—or of scoriated fragments resembling those of furnaces;—or of fragments of subordinate dimensions, approaching in their volume to that of gravel, to which the name of rapilli is given;—or of black volcanic sand often resembling grains of gunpowder;—or of still finer particles in a pulverulent and decomposed form, which, from their appearance of having sustained an extreme degree of heat, have acquired the name of ashes.

The tendency of the volcanos of the basin of Neuwied to form themselves into connected systems, or chains, which have a common direction from north-west to south-east, has been before remarked. (See page 14.) Not only have the earlier eruptions of trachyte and basalt observed this direction, but likewise those of a later date. This is shown in the general map by tracing a groupe which extends from the northerly heights of Kempenich, in a south-easterly direction, along the banks of the Nette to the lava flows near Mayen, or another parallel line of them which is continued from the northerly banks of the Brühl to the vicinity of the Carmelenberg.

It is no objection to the view which is entertained, that although these several volcanos have had a tendency to burst forth in one common line of direction, they should not have been exactly contemporaneous. If any have occurred of comparatively a later date, such more recent ones only afford a presumption that the conditions under which they were developed had long before subsisted;—which predisposing circumstances must be referred to the fissures that in some prior convulsive elevation of the land had observed a common and parallel direction. Through these fractured clefts, gaseous and incandescent products, in boiling up from focal depths, appear at various intervals to have effected their escape.

These general circumstances having been premised, I shall now proceed to notice such volcanos of the lake of Neuwied, as appear to have had their date about the time when the mountains of the Lower Rheinland were undergoing a slight elevation.

In the lower lake of Cologne geologists have remarked, that basalt blocks are found in the Kiesel Gerölle which covers the brown coal formation.

In the upper lake of Neuwied exactly similar evidence is scarcely afforded. When, however, we observe that volcanos of comparatively a later origin had evidently broken out during a period when the waters were maintaining their highest level, we are entitled to suppose that they were contemporaneous, or very nearly so, with a convulsion which was immediately succeeded, as will be shown in a future chapter, by a drainage of the tertiary lakes of the Lower Rheinland.

The volcanos to which I allude appear of nearly the same geological character as that of the crater of Boos, which was the last volcano I described, (page 74,) and which I have been inclined to think was contemporaneous, or nearly so, with some such newer convulsion as we have been investigating, with which the Lower Rheinland was affected. To this common date I would accordingly refer the volcanic eruptions north of the stream of the Brühl. These will be described in the present chapter.

### The Volcanic Eruptions north of the Stream of the Bruhl.

The volcanos which are comprehended under this title, appear to the north of that greater extent of the course of the Brühl, which we trace from Hahnenbach to Burg Brühl, or to the west of that remaining portion of it, which, in diverging at nearly right angles, meets the Rhine near the town of Brühl.

They are probably contemporary, as I have before remarked, with the crater of Boos.

When these volcanos broke out, that part of the Rhine, which is intermediate to the gorge of Andernach and the present site of the Unkel, had apparently suffered little diminution of level; but whether this continued state was not in part owing to the protrusion of a considerable dike of columnar basalt across the Rhine, near Unkel, it is difficult to say. A damming up of the intermediate space must have ensued, by which the lateral valley of the Pfingstbach, parallel to that of the Brühl, would continue to be filled with a tertiary deposit of sand, clay, and brown coal. Consequently, we do not find the lava which was given out seeking the depths of the Pfingstbach, but flowing along its present high bank, where it may be detected covering the remains of a fluviatile deposit, which at the time had nearly filled this ravine. The drainage of the valley of the Brühl must also of necessity have been no less incomplete, though a proof of its exact state at the time is not so satisfactorily afforded as in the case of the Pfingstbach.

The high ridge on which the volcanos north of the Brühl are situated, affords some suspicions that it must have greatly participated in the convulsions which were then going on in the Lower Rheinland. About half a league to the west of the Bausenberg, there is a very small circular lake, the Roddermaar, to be seen on the summit of the ridge, which has been by one geologist considered as a crater maar, while this opinion is discouraged by Steininger, who found no volcanic products to confirm the suspicion. It appears to me, however, to have been a circular fissure, induced during a forcible elevation of the soil, which had served as a medium for the liberation of aeriform fluids.

The extinct volcanos situated on this ridge are those of the Bausenberg, the Herschenberg, the Leileskopf, and the Steinberg.

1*st*, *The Bausenberg*.

This is a crater which appears to the east of the Roddermaar.

The materials which during the violent explosion of aëriform fluids have been projected, besides consisting of cinders and dark-coloured sand, include fragments of altered basalt, of a porous and scoriaceous character, and of a very dark reddish or brownish black colour, which contain fine distinct crystals of augite, and along with these titaniferous iron. There is much felspar contained in the basalt, which, on decomposition, shews a whitish complexion. These larger fragments are accompanied by portions of the rocks through which volcanic products have forced their escape;—among these is mica slate.

The summit edge of the crater walls, which appears composed of scorified basalt blocks, is very narrow, while the descent from it into the interior, now greatly concealed by the foliage of a thick wood, is abrupt and precipitate.

The crater of the Bausenberg, when viewed from the east as we ascend the stream of the Brühl from Burg Brühl, assumes the form of a cone. But, in observing it from a contrary direction, we find that a third part or more of its north-westerly extremity has been destroyed.

This break is supposed to have been occasioned by the issuing of a lava stream, which, having boiled up from the vent of the crater, has afterwards flowed in a north-easterly direction. But I am not quite certain, owing to the very covered state of the ground, if this origin is correctly stated, and if the lava has not rather proceeded from a point exterior to the crater.

This flow, remarkable for the irregularity of its surface, consists of basalt containing augite, showing, in its porosity and degree of scorification, some little of the action of fire. It seems to have taken a direction towards the valley of the Pfingstbach, which, as I have observed, was then undrained, and filled with a lacustrine deposit. In tracing this flow, which has been computed at a league in length and the eighth of a league in breadth, it may be observed on the east of this valley, near Gonnersdorf, where the ravine is deeper, to repose upon the remains of a loamy sandy mass, while, on the west, it is hemmed in by a ridge of clay-slate. Near Gonnersdorf, where the valley becomes deeper, it may be found upon clay-slate.*

* Mr Steininger observes, that in the loamy, sandy mass, called at Andernach *Britz*, are many garden snails of the Helix species, and many of that of Lymneus. The snail shells are partly new; the garden snails partly show their red stripes. This observation I did not verify, as, indeed, my examination of the flow was rather imperfect on account of this as well as the other

*2dly, The Herschenberg.*

Basaltic materials, variously altered by fire, such as fine black sand occasionally agglutinated as if by heat, scoriated fragments of the magnitude of gravel, which bear the name of rapilli, together with larger fragments of slag, appear to have contributed to the formation of the walls of this crater. The cinders assume various colours, as brown, blackish brown, green, yellow or yellowish brown. The latter in decomposing often acquire a whitish coating. Among these various substances we find folia of mica interspersed.

The materials of the crater wall are in several places united by the aid of their lighter particles, and occasionally by a calcareous cement, so as to assume a conglomerate or stratified form. These strata are again alternated by layers of agglutinated volcanic sand, which dip 16° to 24°, or even more, in various directions, to the north, north by west, south-east, &c.

It is not improbable that this crater might for a short time have existed in the form of a crater lake, whence probably the derivation of the calcareous matter which has occasionally served as a cement to the volcanic sand, cinders, &c. A sort of "calc conglomerate" is said to occur on the southerly declivity of the Herschenberg, at a spot called the Altar-stein, which I had not an opportunity of seeing.

The crater, in its present form, shows comparatively little of a ruin. A small part of the wall has sunk in on the east, or rather north-east side, but, when viewed from a contrary position, the crater appears nearly entire.

*3dly, The Leileskopf.*

The Leileskopf is situated near the high bank of the channel of the Brühl. It shows at present nothing more than the trifling remains of a crater.

The products given out by this volcano were scoriated blocks of basalt, rapilli, and ashes, of which the crater walls seem to have been composed.

The destruction of this crater may with a little plausibility be referred to some rise of waters, which might have followed the damming up of the Rhine by the protrusion of the basaltic dike of Unkel. Accordingly, we find tufaceous strata composed of black cinereous particles and argillaceous matter of a fluviatile origin, while nodules of ferruginous clay of fantastic forms, known by the name of Ludi Helmontii, indicate the disturbance or removal of the argillaceous beds, of which these relics may be considered as memorials.

volcanos north of the Brühl, having been out of the limits of the district to which I had originally intended to confine my investigations.

*4thly, The Steinberg, and smaller Basaltic Eruptions near it.*

This hill is situated to the west of the village of Nieder Lutzingen. The basis of it consists of clay-slate or grauwacke slate. Through these strata a protrusion has taken place, which appears as a basalt head. There are also indications of a flow of lava, which must have occurred when the valley was choked up;—but, owing to the steepness of its present banks, the examination is difficult.

The eruption appears in the form of high basaltic columns of a bluish-gray colour, and of a very compact texture, in which zeolite may be traced. None of the rock seems slagged. Indeed, from this circumstance, it has rather an older appearance.

Near this basalt head, a little to the south-east of it, two other eruptions, though very insignificant ones, of compact basalt, may be traced. They appear in the form of small knolls elevated a few yards only above the rocks through which they have been protruded.

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These, with the crater of Boos, are all the volcanos of the basin of Neuwied, which, as far as I have been able to satisfy myself, are referable to the period when certain mountains of the Lower Rheinland were undergoing a slight elevation;—having described which, I shall proceed to notice other important changes that were going on as a result of this extraordinary convulsion.

## CHAPTER XIII.

### THE DRAINAGE, OR DIMINUTION OF LEVEL, WHICH THE LAKES OF NEUWIED AND COLOGNE BEGAN TO UNDERGO.

It was remarked, (page 91,) that the elevation of the chains of the Hundsruck, the Taunus and the Eifel, which then afforded the chief sources to the streams that originally fed the lakes of Neuwied and Cologne, was to be inferred from two traceable events; —the first of these being the accumulation of loose pebbles which covered the lacustrine deposits of the Lower Rheinland;—while the latter, a subsequent one, was the drainage which ensued of its fresh-water lakes.

In the present chapter the later result will be investigated.

Two circumstances may be conceived of as having contributed to, or accelerated the drainage of the lakes of Neuwied and Cologne.

The first of these might refer to the supposed internal convulsions which the basins of Neuwied and Cologne would most probably have sustained in common with the mountains of the Hundsruck, the Taunus and the Eifel, by which their respective barriers would undergo a fracture or derangement favouring the escape of a large body of waters.

That some dislocation or change of level was experienced upon this occasion by the strata of the basin of Neuwied, we are led to suspect by a few phenomena, which, however, are scarcely decisive, as it remains to be shown whether the same are not in part attributable to a much later convulsion in the Lower Rheinland.

One of these indications is the high inclination of the lacustrine strata of the basin of Neuwied exposed in a section upon the road side near Obermennig, (bearing south 70° west from the village,) upon which the much newer lava of Mennig rests. These strata will be found to have an inclination of 22° to the north north-east.

M. De Wyck has noticed, that the tufaceous strata situated between the north of the Laacher-see and its bounding slate hills, especially in the defile from Kloster Laach to Wehr, dip to the north, which, as he adds, can only be explained by a later change in the superficial beds produced by an earthquake.

At the Kirchberg near Andernach, the strata of fine lacustrine sand upon which a much later diluvial bed of *Loess* reposes, exhibit a remarkable dip of 20° to the north north-west.

These several derangements of the newer strata of the basin of Neuwied may be presumed to indicate subsidences which were coincident with more southerly and distant processes of elevation; and it is not improbable that similar phenomena may be detected in the lower lake of Cologne.

Nor is it unlikely that the internal convulsions sustained by the Rhenish fresh water basins might have caused such fractures in their respective barriers as to have in no little degree contributed to the process of lacustrine drainage which was then commencing. But that such a derangement was the sole cause of the effect produced, I am most unwilling to allow. The chief circumstance occasioning it, must be rather sought for in the increased elevation of the hills whence the Lower Rhine and the Moselle have derived their source.

Keeping then in view this increased elevation, and the comparatively reduced level of the basins of Neuwied and Cologne, which received their waters from the mountainous ranges of the Hundsruck, the Taunus, and the Eifel, to which an accession of height had been thus imparted, it will be easy, without even inviting to our aid any other circumstance whatever, to estimate the effects which must have followed.

The increased rapidity and force which a greater declivity or

angle of inclination would impart to the descent of the streams that fed the basins of Neuwied and Cologne, appears to have been so intense, as to have caused a rush of waters, which has gradually succeeded in wearing down their respective barriers.

It may be shown that the drainage of the lower basin of Cologne was a more rapid process than that of the upper one of Neuwied. This can excite no surprise. In any series of mountain lakes communicating with each other, the volume of water striving to effect its escape would of course increase during the progress of its descent. It is evident then, that, *cæteris paribus*, the lowest barrier would the soonest yield to the increasing accumulation of waters.

But this conclusion proceeds upon the assumption, that the materials of each barrier must have afforded equal resistance to the press of waters attempting their discharge. It may, however, be remarked, that the greater rapidity of drainage induced might have been in no little degree connected with the more yielding nature of the materials which constituted the barrier of the lower lake. It was observed (page 20,) that not far from Dusseldorf there were traces of elevated coal measures, which were originally deposited at the foot of the clay-slate hills, and which, most probably, at the commencement of the tertiary period, formed a continuous zone with similar strata near Aix-la-Chapelle or Liege; and that there occurred a little to the north or north-east of Dusseldorf, traces of the green sand or chalk formation, once, perhaps, continuous with the beds of the same description which occur near Maestricht. Now it is almost unnecessary to add, that materials of sandstone, and particularly of green sand, would yield much sooner to the overflows of the lake, than would the barrier of clay-slate by which the waters of the upper basin of Neuwied were confined.

The subsequent and immediate state which was induced in the basin of Cologne, when its barrier yielded to the impetuosity of diluvial torrents, has scarcely been ascertained. M. Boué, from his observations on certain marls at the foot of the Harz near Gladbach and Bansberg, which, I am sorry to add, escaped my notice, supposes that the Cologne basin admitted into it the waters of the ocean, and became a marine gulf. In corroboration of this view, he cites the following marine shells as having been found in the marls: the Patellites primigenus; the Helicites delphinuloides et helicinæformis; the Buccinites arculatus and subcostatus; the Muricites turbinatus; the Buccardites abbreviatus; and the Terebratulites planitiatus. With much deference, however, to this geologist, for whose observations I always entertain the greatest esteem, I am still suspicious that some of the shells enumerated by him might have belonged to much older formations, among

which, indeed, their names are found in geological systems. In this case they would be the result of disintegrated strata of an earlier character. *

But it is not necessary to prolong these details to a greater extent. A process of drainage had commenced, whereby a considerable waste or removal was taking place in the beds of sand, sandstone, plastic clay, and brown coal, successively deposited. The currents of the various rivers described, in their obligation to undermine for themselves channels at a reduced level, would transport to the distant ocean most of the loose sand or sandstone which they had deposited. Being also liable to be acted upon by the periodical or extraordinary inundations to which all large rivers are subject, considerable removals of the beds would, from this cause also, ensue.

## CHAPTER XIV.

### THE LONG INTERVAL OF COMPLETE, OR NEARLY COMPLETE, IMMUNITY FROM VOLCANIC ERUPTIONS, WHICH THE BASIN OF NEUWIED ENJOYED, AND ITS ADVANCED STATE OF DRAINAGE.

In the sequence of geological phenomena which we are employed in investigating, it has been observed that they range themselves in an order of time into two series.

In the first of these, we find that the fresh water basins of the Lower Rhine were gradually filled with a lacustrine deposit of sand, sandstone, clay, and lignites. This was the period characterized by the eruption of trachytes and early basalts.

In the second, and ensuing series of phenomena, which we are only beginning to trace, we have done little more than notice the convulsion by which the mountains of the Hundsruck, the Taunus, and the Eifel sustained a certain degree of increased elevation; by which eruptions of an altered character began to succeed the trachytes and early basalts of the former period; and by which the fresh water basins of the Lower Rheinland began to undergo a process of drainage.

To these convulsions succeeded a long interval of complete, or nearly complete, immunity from volcanic eruptions, the circumstances of which, as well as the advanced state of drainage eventually displayed by the basin of Neuwied, will employ us in the present chapter.

* Geognostiches Gemälde von Deutschland, p. 344, and 363.

The geological history which we have been exploring has brought us to a late period of the tertiary epoch, when we lose all traces of the existence of palms. Hence we may infer, that the climate of the west of Europe was fast approaching to its present refrigerated state. The rains which had been poured upon the earth in inconceivable torrents, sufficient to produce, in the action which they exerted upon rocks of clay-slate, the fine state of disintegration recognizable in the sand and plastic clay of the basins of Neuwied and Cologne, were at length beginning to abate.

Such was the new condition of the Lower Rheinland when its climate was deteriorated, when its palms had disappeared, and when the oak, the beech, or the pine had remained in indisputed possession of the soil. In exchange for the satisfaction which our inquiries have hitherto received of the progress of vegetation through the medium of submerged deposits of brown coal, we are now directed to examine rather different sources of information. They are conveyed to us by means of such deep beds of common peat as can be shown to have subsisted previous to the great diluvial deposits of the north of Germany, or of the British islands. Upon the heights of the Veen, situated to the west of the Rhine, an ancient deposit of clay is surmounted by beds of turf to the depth of sixteen feet. The lowest of these, which contain wood of an obscure character, much resemble beds of true brown coal; of which they were probably the immediate successors. In the strata of turf succeeding to the deepest ones, birch-wood, fir-cones, or hazelnuts are found, while the uppermost layers of hard or swampy moss connect the intermediate series of beds with the vegetation of the present day. And thus may the more recent forests of the Rheinland boast a derivation from the ancient stock which is to be recognized in the fossil wood of the brown coal formation.

Regarding the animals which might have existed at this time on the borders of the Rhenish lakes, we are destitute of intelligence.

That a great disintegration of the primary rocks of the basin of Neuwied had taken place during this long interval of complete, or nearly complete, immunity from volcanic convulsions, is evident from a variety of circumstances. It will be shewn, when we come to investigate later series of eruptions, that they occurred at a time when such deep volcanic basins as those of Fusel, Wehr, or Rieden had, by the gradual wearing away of their solid barriers, been greatly drained of their tufaceous contents; and when the basin of Neuwied had likewise experienced, from a similar gradual wearing down of its gorge at Andernach, a considerable diminution of the level of its waters, along with a formidable removal of its lacustrine beds.

Various newer deposits must have ensued during this long interval of volcanic quiescence; but owing to the rapid process of

lacustrine drainage which was then going on, it can scarcely be expected that they should have possessed any considerable permanence. Some of the lower beds of the gerölle or gravel of the basin of Neuwied may be safely referred to this period. Along the course of the Rhine, and of the lakes formed by it during its course, there must necessarily have been a number of minor collections of water, where the process of drainage would in some degree have kept pace with that of larger lakes. Emptying themselves, therefore, one after another, such inundations must necessarily have involved along with them larger stones and boulders;—which deposit would in many places have filled up the void occasioned by the removal of the prior lacustrine deposit of quartzose sand and plastic clay, and would more particularly have lined the marginal heights of the basin.

Such are the few glimpses of which I have been enabled to avail myself, regarding the long interval of quiescence from volcanic convulsions enjoyed by the basin of Neuwied.

That it was a complete state of quiescence I am scarcely authorized in affirming. Some few volcanos occur, of the relative age of which I am in some little degree of doubt, having suspected that they might have had a precedence in date over that of many others remaining to be described;—and thus, that they might have possibly broken in upon the tranquillity of this otherwise peaceful interval. The doubts which I have entertained will be expressed in the course of this inquiry.

In general terms, however, it may be safely asserted, that very few, or even none of the volcanos yet to be investigated, appear to have been developed until the drainage of the basin of Neuwied had made a considerable degree of progress, and, until the barriers which confined such mud deposits as those of Rieden, of Fusel, or of Wehr, had, in correspondence with the erosion of the common channels by which they were drained, been greatly worn away.

## CHAPTER XV.

THE CHAIN OF VOLCANOS, TO BE TRACED IN A DIRECTION OF NORTH-WEST AND SOUTH-EAST, FROM THE HEIGHTS OF KEMPENICH TO THE LIMITS OF THE HOCHSTEIN.

Agreeably to the tendency which the volcanos of the basin of Neuwied have had to arrange themselves in a direction from

north-west to south-east, a chain of them may be traced along the easterly bank of that branch of the Nette which takes its rise from the heights of Kempenich to the lava flows near Mayen. During this part of the course of the river, there is a descent of about 700 feet; the stream which flows close to the town of Kempenich having been computed at 1237 Rhenish feet above the level of the Rhine at Coblentz, while the town of Mayen is estimated at 549 feet. The extent of this chain of volcanos disposed along a declivity stretching from north-west to south-east, may be estimated at about nine English miles, while the breadth of soil which it occupies does not exceed perhaps three miles.

The volcanos of this chain, I mean in the present and two following chapters to consider in their order, as we observe them on the east of the Nette from the heights of Kempenich to Mayen;—commencing with those which extend from the hill near Heidnerhof to the limits of the Hochstein.

But before proceeding in this investigation I might remark, how difficult it is to determine the comparative age of each volcano in this part of this chain. It is highly probable, and this is all that can be said, that the several individuals of it had a date of eruption, which, if not exactly contemporaneous, did not admit of very distant intervals.

Most of the volcanos which extend from the heights of Kempenich to the limits of the Hochstein form a set of slag hills, or slag cones, as they have been often named by geologists. Upon the distinctive character of such eruptions, some previous information may perhaps be considered necessary.

It need be scarcely remarked, that when the volume of elastic fluids discharged from volcanos is considerable, regular craters, more or less extensive, are found, the walls of which are wholly or in part composed of the loose materials which I have described.

But in other eruptions, which often bear the name of *slag hills*, or *slag cones*, no regular crater can be traced. It is certain, nevertheless, that even in these examples there has been an extrication of elastic fluids. Gaseous matters have been disengaged, though in a very small proportion when compared with the amount of basaltic blocks, of scoriæ, of black sand, or ashes that have been given out. Thus, in conceiving of such volcanic materials during the actual course of their propulsion through a very confined vent or orifice, it is evident, that, in their descent and accumulation round a small central aperture, they would in their increasing height, slope, and diameter, gradually put on the configuration of a cone; and that upon the relaxation of the volcanic activity, whereby gaseous and scoriaceous products would cease to be ejected, the central cavity would sooner or later be choked

up by the internal subsidence of the same accumulatated materials. Hence, a slag hill, or slag cone, is an eruption differing originally from a crater-formed volcano in no other circumstance except the lesser dimensions of its vent or orifice, which, as a consequence, must have undergone obliteration.

The volcanos, chiefly slag-hills, to be described in the present chapter, have their sites, 1*st*, in the hill of Heidnerhof; 2*dly*, the margin of the basin of Fusel; 3*dly*, the hills which bound the basin of Wehr; 4*thly*, near Gleis; 5*thly*, north of Weiber; 6*thly*, between Wabern and Volkesfeld; 7*thly*, west of the Abbey of Laach; and, 8*thly*, near Bell.

### 1*st*, *The Hill of Heidnerhof.*

About three quarters of a mile to the north-west of the town of Kempenich, estimated, as I have observed, at 1237 Rhenish feet above the level of the Rhine at Coblentz, an eruption is to be observed upon a hill of very moderate height above the level of the valley, near Heidnerhof.

This is a slag hill, which, from the very incompletely drained state of the lake of Kempenich at the time it appeared, I have been in doubt whether or not to consider as of a date entitling it to a place among the very few eruptions which might have occurred during the long interval of comparative immunity from volcanic convulsions which the basin of Neuwied enjoyed.

Whether any considerable vent or crater was ever formed in this site may be doubted. The summit of the hill is covered over with large blocks of scorified and slightly cellular basalt, in the composition of which, crystals of augite are sparingly observable. Within the pores of these loose masses, I noticed occasional white efflorescences, which yet remain to be chemically examined. Intermixed with these masses of slag, are rapilli, as well as scorified fragments of still lesser magnitude.

A little to the north-east of the town of Kempenich, at the northerly foot of the volcanic ridge of trachyte, or rather perhaps leucostine, (described page 60,) there may be found superimposed upon far older beds of tufa, which had overflowed in the form of volcanic mud from the crater of Fusel, tufaceous beds of a blackish-brown colour, which are referable to cinereous particles washed down from the slag hill of the Heidnerhof, and consolidated under water in the form of strata.

### 2*dly*, *The later Eruptions on the Margin of the Volcanic Basin of Fusel.*

Certain eminences impart distinguishing features to the margin of the basin of Fusel. Of these is the trachytic cone situated

between the villages of Engel and Olbruck; another volcanic point is the Engelerkopf; while an intermediate one is at Bahlhof, situated about three quarters of a mile north of the village of Engel, where a later eruption appears upon an easterly declivity, resting on the previously formed felspathose tufa of the basin of Fusel.*

In this site there has been a protrusion of lava, which is shewn in the very porous and scorified dark-coloured basalt containing augite and some little black mica, which is quarried for millstones. Large lava blocks are strewed about the hill, mixed with rapilli, with black sand and ashes.

Whether any regular crater was ever formed in this site, and subsequently effaced by diluvial torrents, is doubtful.

The eruption appears to have occurred at a time when the basin of Fusel was in more than a half-drained state. Cinereous particles have been evidently washed into various depressions, and, by the aid of water, have formed dark-coloured tufa. This appearance is observable on the road from Engel to Fusel, and upon the northerly declivity of the Engelerkopf. We even trace more recent tufaceous strata at the distance of one or two miles northwards from the basin of Fusel, where, to the south of the hill of Olbruck, they repose upon a prior deposit of trachytic tufa. The difference between the older and later deposit is very discernible. The latter appears in the form of a blackish or brownish volcanic mud, containing argillaceous or sandy matter, small cinereous fragments, black mica, and reddish-brown crystals of augite.

*3dly, The later Eruptions of the Hills which bound the ancient Volcanic Basin of Wehr.*

The eruptions now to be described consist of basalt slag, in which crystals of augite are contained, of rapilli, and of black sand. They evidently occurred when the basin of Wehr, which had been previously filled with trachytic tufa, had undergone a considerable advancement of drainage.

The volcanic phenomena, as they were originally presented, must have been so similar in every point of view to those of the hills of Bahlhof and Heidnerhof, that they may be dismissed very concisely.

It would seem that from the summit of two adjoining hills on the south and south-west of the basin, at least three eruptions have occurred; the most considerable one having taken place from the more northerly eminence of the two. Also, on the north-east of the basin a fourth eruption appears of a similar character.

From these heights great quantities of volcanic sand or cinders have been washed into the half-drained basin of Wehr, which,

* M. De Wyck (in page 34 of his treatise,) describes this volcanic eruption as intermediate to the Schorkopf and the Schellkopf.

having been mixed with the disintegrated substance of the clay-slate mountains, constitute the dark-coloured tufaceous strata, the remains of which, in lining the basin in a consolidated form, may be found resting on the older trachytic tufa of a light yellowish colour.

*4thly, The Eruption west of the village of Gleis.*

To the west of the village of Gleis, being close to the site of the ancient lake of Gleis, there has evidently been a small slag hill, like those which I have described, where the evolution of elastic fluids has been much out of proportion to the black sand, cinders, and larger fragments of basalt slag discharged. Some of the black sand was washed into the bed of the half-drained lake, where a few strata of black tufa are found at the foot of the hill.

*5thly, The late Eruption of Basalt Slag, &c. a little to the north-west of Weiber.*

A little to the north-west of the village of Weiber, situated upon a branch of the Nette, this eruption, which continues to be of a character similar to the preceding one described, may be observed. A small knoll, situated on the east of the stream, is capped with masses of basalt slag, while volcanic sand and ashes have been washed into the valley beneath, where, in mixing with older earthy matter, they form the darkish coloured strata, which rest upon the earlier trachytic tufa of the basin of Rieden.

*6thly, The Eruptions intermediate to the Villages of Wabern and Volkesfeld.*

In this description, the village of Wabern must not be confounded with the one last alluded to of Weiber, the names of which are very similar. Wabern is about a mile south of Weiber, while Volkesfeld is about a mile east by south from Wabern.

Between Wabern and Volkesfeld are two small hills, capped with basaltic fragments, which are distinguishable from older basalts previously protruded around the margin of the crater of Rieden, by their porosity and scorified state, as well as by the dark-coloured tufa, resulting from black volcanic sand and ashes, which is found at their base, but more particularly at the base of the southerly knoll.

*7thly, The Eruption discernible on a Three-peaked Hill west of the Abbey of Laach.*

There is rather a considerable hill, of the local name of which I am ignorant, situated a mile and a quarter to the north-east of the Ovenstone quarries of the Gansehals, and about the same distance due west from the Abbey of Laach, which has been the

seat of volcanic explosions. It puts on the appearance of a long-ridged hill, with three peaks or heads; but it is only from the two more westerly points that the eruption has taken place. This hill, like many preceding ones described, appears to have allowed the escape of elastic fluids, as well as slight flows of basaltic lava. This is to be inferred from the black volcanic sand and cinders which are lodged round the base of the hill, and from the slagged basalt blocks, in which is contained augite, protruded from, or strewed over its central summit and westerly declivity.

*8thly, The Appearance of a Crater near the Village of Bell.*

On the south-east of the village of Bell, a ridge of clay-slate is so hollowed out in a circular form as to put on much of the appearance of a volcanic crater. On one side appears the segment of a circle, indicating a diameter of scarcely half a mile, which on the west is lost in a swampy meadow, that conveys the suspicion of a former crater-lake. Below the supposed wall of the crater are strata of dark-coloured ashes, mixed with sand.

## CHAPTER XVI.

### THE HOCHSTEIN.

Taking leave of these rather insignificant eruptions, we fall in with far more important ones in our south-easterly progress,—the first of which is the Hochstein.

A high hill of clay-slate lies to the south-east of the basin of Rieden, being distant about three quarters of a mile south by west of the Ovenstone quarries of Bell, which cannot perhaps be estimated at less than 1800 feet above the level of the sea, though on this question I cannot offer a very accurate opinion. It is an isolated eminence, and, in its original form, was probably crowned by only one peak. But, in consequence of a protrusion of lava from a lofty point north-west of the summit, whence a basaltic flow has issued, it now appears with two peaks of nearly equal altitude. The name of the Hochstein is given to the volcanic pinnacle.

This is one of the volcanos, which, more perhaps than almost any other, I am inclined to think might have interrupted a long period of comparative quiescence from igneous explosions. The chief reason which I have for this opinion is, that the erupted lava, in its mineralogical character, rather resembles that of the rocks of earlier origin in the district of the Eifel, where numerous

volcanos broke out during an interval, which, in the basin of Neuwied, was comparatively undisturbed.

But, to speak candidly of this opinion, it is at the best merely conjectural. As the base of the Hochstein is elevated much above the ancient level of the lake of Neuweid, there is no definite circumstance to prove the state of drainage which might have then subsisted. For, as I have before stated, the varied level of the waters displayed in this basin becomes, in questions of comparative volcanic date, almost our sole chronometer.

From this clay-slate hill there has assuredly been an extraordinary volcanic explosion.

The first incident in this eruption was probably the liberation of elastic gases, which was accompanied by a great discharge of fragments of basalt slag, of rapilli, of black sand, of ashes, and of those peculiar volcanic balls which the French describe under the name of *bombes*, or *larmes volcaniques*.

These ejected substances, most of which have been subsequently washed away by rains, or removed by currents, are found around the base of the hill under various circumstances.

In some sites, as on the south-east of the Hochstein, the rains which have washed down the rapilli and black sand, have caused them to be mingled with the alluvium of the clay-slate hills, consisting of earthy matter and small fragments of stones. In this accumulation, balls of basalt (*larmes volcaniques*) may be found. In other sites, however, we find these ingredients consolidated in the form of a tufa of a dark brown colour.

In another site, as on the south-westerly flank of the Hochstein, in a declivity intermediate to this mountain and the Hoch Simmer, we find, resting upon a prior deposit of trachytic tufa, the result of an overflow from the basin of Rieden, a bed of rapilli and volcanic sand, which varies in its depth from 18 to 24 feet.

The black sand of this volcano appears to have been even carried to a greater distance, namely, to the site of the present village of Obermennig. In a section on the road side, from which the village bears north 70° east, where we find plastic clay and sand resting on the clay-slate, indicative of the ancient margin of the lake of Neuwied, strata appear, which consist in one place of a dark-coloured tufaceous mud, (wherein I detected the shell of a planorbis,) and in another site of trachytic tufa, washed from the basin of Rieden, and confusedly intermixed with black sand and ashes; its height being 6 feet from the bottom. Higher up, for 4½ feet more, the blackness seemed to increase. This is probably the deposit observed by M. Steininger, and which, as far as I can learn from his description, was a bed, fifteen feet thick, of black sand, among which smaller rapilli were intermin-

gled. This eruption, which preceded the great lava flow of Mennig, by which it is covered, cannot well be referred to any volcano except that of the Hochstein. At the time when it occurred, the basin of Neuwied must, I conceive, have undergone a considerable diminution of its level.

It was probably in a more advanced stage of these ejections, that a discharge of pumice of a white colour took place, which we find on the south-west side of the Hochstein, reposing upon previously formed cinereous strata of a darker colour. This pumice appears, in fact, to be little more than small rapilli deprived of their colour by a prolonged intensity of heat.

During this eruption various fragments of the rocks through which elastic fluids had forced their escape, along with folia of mica, appear to have been strewed about the hill. Of these is a whitish coarse-grained granite, the felspar of which is variously reduced to the form of a kaolin, or of an enamel. One variety of the latter assumes the appearance of a beautiful pistachio green coloured glazing, variegated with blood red spots, the striking tints of which have resulted from the intermixture of some substance remaining to be examined.

Lastly, a flow of basaltic lava appears to have issued from the orifice which gave origin to the loose volcanic products described.

This flow, which may be traced from the westerly peak of the hill, named the Hochstein, seems to have descended in a direction north by east, and to have continued its rugged course, which is evinced by the presence of a confused and almost insurmountable assemblage of immense lava blocks, for a distance of nearly three quarters of a mile into the valley leading from the Bell quarries to Obermennig, where, in meeting with some obstacles now no longer evident, it has terminated abruptly, and exhibited, as the result of its congelation, lofty lava walls.

Again, as on the opposite side of the Hochstein, there are indications of a slighter flow, probably a subordinate stream of the last described one, which at the mouth of the orifice took a different course. Large blocks of basaltic lava are plentifully strewed over the ground in a direction south by west.

The lava of the Hochstein shows a variety of character. In some places it appears as a hard compact basalt, which, being characterized by the presence of small grains or concretions of olivine, the largest of which appear about the dimensions of an inch, may be described, in the language of Brongniart, as a *basanite compacte peridoteux*. In other places augite takes the place of the olivine. Lastly, the lava assumes the form of a very porous, black, or reddish-black basalt.

In the same lava stream, melanite, or black garnet, is said to have been discovered. This mineral has not fallen within my own observation.

# CHAPTER XVII.

## THE HOCH SIMMER; THE ERUPTIONS OF ETTRINGEN, AND THE LAVA FIELD OF MAYEN AND KOTTENHEIM.

The eruptions to be described in the present chapter form a continuation of the chain of volcanos which we have already investigated in a direction of north-west and south-east from the heights of Kempenich to the hill of the Hochstein. The remaining phenomena presented in this chain, which we trace from the Hochstein to the vicinity of Mayen, are, 1*st*, those of the Hoch Simmer; 2*dly*, the eruptions of Ettringen; and 3*dly*, the great lava field of Mayen and Ettringen.

### 1*st*, *The Hoch Simmer*.

An isolated hill, situated in a direction south by west from the Hochstein, has been the seat of a considerable volcanic crater. It is named the Hoch Simmer.

The basis of the hill is a grauwacke slate of a very arenaceous texture, in which numerous impressions of marine shells may be traced.

The original diameter of the crater, before a part of its walls had suffered destruction, may be loosely rated at about three-eighths of an English mile. The height which its walls have attained has been estimated at about 1100 Rhenish feet above the level of the stream of the Nette, which washes its base, or at 1695 feet above the level of the Rhine.

The crater walls are ascended with difficulty. Independently of their steepness, they are in a great measure formed of small dark-coloured cinders, or basaltic rapilli, which give way to the feet, interrupted only by occasional masses of a reddish brown basaltic slag, which everywhere project from the surface.

Interspersed among the volcanic sand of a greyish brown colour with which the neighbouring hills are covered, M. Steininger has stated that such other mineral products are discoverable, as particles of magnetic ironstone, often crystallized in octahedrons, as glassy felspar, augite, titanite, melilith, and erigin.

From this hill one or more flows of porous and scorified basaltic lava appear to have proceeded, whence, probably, the destruction of at least a third of the circumference of the crater walls. While on their northerly side their integrity appears nearly perfect, their demolition in an opposite direction, namely, to the south, or south by east, appears no less complete.

It is not, at the same time, easy to say whether each flow proceeds

from the crater itself, or from some point of eruption external to it. There has, for instance, been a minor eruption to the north-west of the crater, where a small eminence formed by slag and cinders has acquired a nàme, in contradistinction to the Hoch Simmer, of the Klein Simmer. It would appear in some way or other to connect itself with the Hoch Simmer, either by a prolonged ridge, indicative of a flow in this direction, or by the ruins of an independent crater.

We observe a slight flow maintaining a direction west by south over beds of volcanic ashes and sand, towards the high banks which bound the Nette, where it is very observable on the road which leads from Saint Johanns to the castle of Burresheim.* The basalt is much scorified, of a reddish brown colour, and more or less porous.

M. Steininger, who appears to have examined the Hoch Simmer with much attention, conceives that a flow has taken place from a point of eruption exterior to the crater, from which it is divided by an interval of slate rocks, which precludes the supposition that it had an internal origin. This flow is conceived by him to have taken a south-easterly direction towards Mayen, where it has in part contributed towards forming the great bed of lava, whence valuable millstones continue to be quarried. But the correctness of this view has been doubted by other observers, who are inclined to refer the origin of the Mayen lava field exclusively to the volcanic site of Ettringen.

### *2dly, The Eruptions of Ettringen.*

The eruptions to be now described may be found about a mile to the east and south-east of the Hoch Simmer.

They originally took place on the westerly margin of the ancient lake of Neuwied, when its waters by drainage had been considerably diminished in their elevation. Thus, if a line be drawn from a point a little to the north-west of Mayen, where abundant traces of plastic clay are observable, and thence a short distance along the course of the Nette to Ettringen, we shall find that to the west of the village and south of the church, we shall meet with other traces of the same deposit in a deep bed of fine ochreous or saffron-coloured sand. And, again,—if from Ettringen the westerly line be irregularly prolonged towards the town of Obermennig, still further indications of the same fresh water deposit will recur, while from this last mentioned site the line of margin, if necessary, may be yet prolonged to the vicinity of Laach, where we shall fall in with the original northerly boundary of the same lacustrine expanse.

* M. De Wyck describes this flow as being in some places covered by a marly bed of earth, from which it has received infiltrations.

The eruptions which have thus occurred on the margin of the ancient lake of Neuwied during a reduced state of its level, when it was not, perhaps, higher than 600 feet above the level of the Rhine at Coblentz, comprise, what appeared to me, eight or nine slag hills, or slag cones, situated to the north-east, east, south-east and south, of the village of Ettringen. These slag cones I have been disposed to consider as so many independent points of eruption; but, from the approach which at least five of them make towards a semicircular arrangement, other observers, among whom is M. Steininger, have been led to suppose that the walls of one large and partly demolished crater are indicated. I am myself scarcely able to view these phenomena in the same light. It rather appears to me, that these slag hills afford an example of that species of volcano which I have described at the commencement of the fifteenth chapter; where gaseous fluids accompanied with ejections of volcanic ashes, of rapilli, and of larger blocks of scoriæ, have made their escape, not through one large, but through various small independent apertures, which, upon the cessation of the volcanic activity, have been readily choked up by ejected matter, and obliterated.

The slag hills of Ettringen are distinguished by various names, among which are the Buden Bellerberg, or Kottenheimer Buden, the Mayen and Ettringen Bellerbergen, &c. But a great uncertainty subsists in the determination of names to the hills of the Lower Rhine.

The products of the Ettringen volcanos differ too little from those of the other sites described in the present chapter, to demand a particular description. In one of the slag cones which I examined, which was composed of small cinders, wherein were interspersed large blocks of porous basalt slag, and occasionally of more compact masses, I found fragments of granite, occasionally characterized by a large proportion of hornblende, as well as fragments of micaceous schist changed by the action of heat to a copper colour. Glassy felspar, as well as a saline efflorescence in which lime appears to enter as an ingredient, may be also found filling up small drusy cavities in fragments of basaltic scoriæ.

*3dly, The Lava Field of Kottenheim and Mayen.*

The origin of this flow is by no means exactly ascertained.

M. Steininger refers a more southerly portion of it, not to the Hoch Simmer itself, for in this case, as he observes, it would have covered the clay-slate hills half-way down, but to some point a little distant from the crater. He also imagines that upon the high flat between Mayen and Kottenheim, this flow has united with a much more considerable one proceeding from the Ettringen volcanos.

M. De Wyck has conceived, that, within the limits of the Kot-

tenheimer Buden, and the Ettringen and the Mayen Bellerbergen, where a crater is supposed to have subsisted, the flow had its origin. He supposes that the lava burst these limits, and in taking a south-easterly, and afterwards a diverging, or south-westerly direction, abutted against the Mayener Bellerberg, which is the most southerly slag hill of the groupe, and eventually breadthened itself towards the Mayenfeld, or the valley of the Nette near Mayen.

A third observer, M. Schulze (*Archiv. fur Bergbau de Karstein*, Vol. xiii. cap 2, p. 386,) adopts the same view as that of M. De Wyck. He supposes that the origin of the lava flow is exclusively referable to the Kottenheimer Buden, the crater of which, from the north-west to the south-east, is covered with it to the depth of twenty feet; that the south westerly part of the crater, which is a ridge of 200 toises in length, by 10 broad, particularly shews the activity of this ancient volcano, its declivity being covered over with blocks of reddish and grey lava. The same author, after alluding to the abutment of the Mayener Bellerberg, a slag cone of 25 toises in elevation, then traces the flow to the margin of the Nette, half a league below Mayen, where he observes it to fill an ancient valley, reposing upon grauwacke schist, with an inclination to the south-west.*

Such are the opinions of the origin of the lava flow of Kottenheim and Mayen which have been advanced. That the origin of the whole, or at least the greatest part of the flow, may be traced to the vicinity of Ettringen, I am willing to admit. But that it is necessary that the vent of a large crater should be the medium of its developement, may be readily disputed. In the phenomena of recent volcanos it has often been found, that a very small orifice has been the channel through which a column of lava has issued, which, upon its egress, has breadthened itself over a wide plain; and as an extensive crater in the vicinity of Ettringen must be still considered as problematical, the flow may probably have owed its origin to one or more small and obscure points of eruption yet remaining to be detected.

The extent of this flow I have not been enabled to accurately ascertain. It appeared to me traceable for a distance of an English mile to a mile and a-half from north to south, and from half a mile to a mile from east to west.

The mineralogical character of this lava field is of interest. It may be considered as consisting of a hard brownish, or bluish black basalt, which is sometimes compact, but far more frequently scorified. It contains numerous pores, on account of which, as well as

* The original dissertation of M. Schulze I have not had an opportunity of seeing. This account I have abstracted from the Annales des Sciences Naturelles, &c.

its conjoined hardness, it is well adapted for millstones. I could trace in it very little augite.

Numerous fragments of primary rocks appear entangled in its substance. In my own observations I detected, 1*st*, fragments of a pale-coloured granite, much affected by fire, the surface being vitrified, or run. Other varieties, the sienite of the older mineralogists, contained much hornblende and some little quartz:—2*dly*, entangled fragments of gneiss. These are rather sparingly found:—3*dly*, entangled fragments of mica-slate:—4*thly*, of the common clay-slate of the district:—5*thly*, of quartz:—6*thly*, included portions of iridescent or opaline felspar possessing a comparatively dull lustre, which is discovered wholly or in part filling up pores like drusy cavities.

Calcareous matter, in the form of nests, is said to have been found in the lava, which is described by Steininger as a fine earthy bluish, and reddish-white limestone. The same geologist also speaks of spinellin and porricin having been detected.

This lava flow, in its divisionary structure, forms colossal pillars, said to be from thirty to forty feet high, the undermost bed of which is a firm lava, where there are few or no regular divisions or separations. Its surface is very uneven, being often thrown up in the form of prominences, or small knolls.

These details conclude what I have to say upon the lava field of Kottenheim and Mayen.

It has been conceived, and with reason, that subsequently to this flow there has been an activity of some adjoining volcanos, to which the surmounting of blocks of lava, of evidently a later date, and of a covering of dark-coloured volcanic sand, may be referred. M. Schulze suspects there has been a more recent activity in the Buden Bellerberg.

The pumice found resting upon the lava may, I conceive, be referred to even later volcanic eruptions.

## CHAPTER XVIII.

### THE LAVA FIELD OF MENNIG.

In the three last chapters we have been exploring a chain of the more recent eruptions, which we trace from the heights of Kempenich to Mayen in a direction from north-west to south-east. In the remaining volcanos likewise, of a more recent date, namely, those which run from the north of the Brühl to the

Humrichs and the Carmelenberg, although, in their respective developement, they have observed more distant and irregular intervals of time, the same common direction of north-west and south-east is recognizable. These eruptions, on account of this irregularity of developement, I am precluded from describing in any other way than agreeably to the order of time which they may be supposed to have observed; for which reason, indeed, the volcanos north of the Brühl, presumed to have been the oldest of the system, were the first which met with an investigation.

The eruption which I propose considering after that of the lava field of Kottenheim, is another of the same character, situated a short distance north-east of it, which is that of Mennig. It differs from the last in being a volcanic rock, neither exactly composed of basaltic, nor of felspathose ingredients, but forming a sort of intermediate product, approaching to the character of Mr Poulett Scrope's *greystone*.

Of this rather more considerable lava field it may be generally remarked, that, in its northerly boundary, it is met with about a mile to the south of the Laacher-see. It has been commonly described by authors as occurring in the beautiful plain of the Maifeld, where two villages appear in its course, the one, Obermennig, situated to the west of it, and the other Niedermennig, in a central site. Its extent, which must be considered as very irregular, may from north to south vary from one to two English miles, while from east to west it may perhaps be estimated at two miles.

When this eruption took place, the basin of Neuwied had incurred a considerable diminution of its level, whereby much of the tertiary deposit of the lake, mixed with tufaceous matter, had been laid dry. This is evident from the circumstances under which the remains of lacustrine strata are found which we trace on the borders of the ancient lake, near to the village of Obermennig. The loam and potters' clay mixed with tufaceous strata, and containing fragments of shells, as of the planorbis, which beneath the waters of the basin had been deposited, became subsequently surmounted by the debris or soil of the slate mountains, which, as is evident in one place, the roots of trees growing on the margin of the lake had penetrated. These beds had again been covered with black volcanic sand mixed with rapilli, referable, most probably, to the previous eruption of the Hochstein. In one place, the sand appears drifted to the depth of fifteen feet or more, while, in another, it seems to have been submerged, and, in this state, to have approached to the condition of dark tufaceous strata. Lastly, over this deposit a portion of the lava appears which forms the margin of the great lava field of Mennig.

After these very general observations, I shall consider, 1*st*, The origin of the lava flow; and, 2*dly*, Its mineralogical character.

SECTION I.—THE ORIGIN OF THE LAVA FLOW of MENNIG.

The point of origin to which this lava may be referred is involved in the greatest obscurity.

By some authors the lake of Laach has been conceived to be its source; the fact having been lost sight of, that the volcanic rock of Mennig has no sort of mineralogical resemblance whatever to the igneous products of this crater.

M. De Wyck has imagined that this flow has its origin in a crater to the south of the Laacher-see, one wall of which he supposes to have been formed by a hill named the Tullenberg, in conjunction with another named the Wingartzberg. This source certainly escaped my own observation, nor has it been noticed by such other observers as have investigated this vicinity with the greatest attention. With regard to an absolute crater existing in the site referred to, I very much doubt the assertion. I observed myself nothing more than slag hills. On this question the testimony of M. Steininger, with which my own observations correspond, appears decisive. He considers that it is in vain to attribute this lava either to the crater or margin of Laach, when it is recollected that a similar lava never appears round the lake itself, nor in the declivities of the mountains which surround it, nor even in the nearest deepening of the valley towards Mennig.

The same geologist, M. Steininger, has referred the origin of this lava stream to a small knoll, much concealed by verdure, and little elevated above the surface of the neighbouring ground, which is situated about half a mile west of the town of Obermennig. He states, that he found west, and not a quarter of a league, from Obermennig, a hill of inconsiderable height, (nearly opposite the Forst, or Obermennig Kopf,) which he describes as one of the volcanic cones lying in the line of the Hochstein. The hill was bare, and consisted on its westerly declivity of grauwacke slate, which stretched from north to south. In proceeding from the summit, a small distance towards Mennig, in which direction the hill continued to flatten, he found the line of direction to change from west to east, being the same as that of the lava stream. Beyond this, he adds, there is nothing exposed but shattered slate rock, covering trass [or tufa;] while under the trass is loam and some little calc tufa. Afterwards he arrived at the projecting lava, over which he was conducted to Obermennig.

This is the view which M. Steininger has taken of the origin of the lava flow of Mennig, regarding which it may be remarked, that no objection to this supposition can be possibly entertained on the score of the lava stream having flowed from a hill neither

remarkable for its height, nor putting on the form of a crater. The phenomena of volcanos show frequent instances of lava flows originating from a point of no degree of prominence or peculiarity whatever.

There is, however, one other possible supposition, to which no geologist, that I am aware of, has yet adverted. It is that which would connect the origin of the lava flow with some deep rent or fissure produced during one of the violent convulsions or agitations to which this district has at intervals been subjected. Such a fissure might have had a date referable to the formation of the central aperture of the lake of Laach itself, agreeably to the remark of M. Von Buch before cited, (page 23,) that, if we suppose a succession of solid and unelastic strata to be suddenly acted upon from below by the expansive force of elastic fluids, it is evident that not merely would a central aperture be formed, but that this strain would occasion a number of lateral fissures. Granting, then, to the existence of a fissure this origin and early date, it must be regarded as nothing more than a predisposing circumstance, which, during a subsequent explosion, in the little resistance which it would offer to the ascent of a volume of lava, would greatly favour or promote its escape, and even provide for its final lodgement a deep bed.

That a considerable rent of this kind can be traced, I am disposed to assert as susceptible of proof. The flow of lava has certainly found a bed in a cavity so deep, that its greatest profundity has not, to my knowledge, been hitherto estimated. At the same time, if such a rent has actually favoured the ascent and extravasation of a column of lava, the question still remains open for determination,—if it may not have been rather coincident with some later convulsion, than that which produced the great central aperture of the Laacher-see?

In replying to this last question I would even attempt to reconcile each view, by supposing, 1*st*, That the bed in which the lava of Mennig found a lodgement was a fissure which was originally the consequence of the great strain occasioned during the escape of elastic fluids from the central aperture of Laach; 2*dly*, That, during subsequent convulsions, by which, as I have explained, (page 100,) the lacustrine and tufaceous strata of Obermennig underwent a remarkable dip of 22° to the north north-east, this ancient rent might have been still further widened; and, 3*dly*, That even a still later widening of this ancient rent might have been coincident with the ascent of a column of lava.

That such a view is not chimerical, will be seen in a future page, where it can be absolutely shown, that, near the close of the volcanic explosions of the basin of Neuwied, the latest convul-

sion of this district still further affected the presumed fissure of Mennig, even after it had been filled with congealed lava, so as to cause the imbedded volcanic mass to separate into a yawning cross rent.*

The form, extent, and even direction of the original fissure, owing to the lava which in ascending through it appears to have boiled over its sides, must necessarily be involved in obscurity. Its direction was, I suspect, from north to south, in which case it could scarcely have been much less than two English miles in extent. To the centre of it the present site of the village of Niedermennig may be probably referred.

We must, lastly, conceive of this fissure, through which the lava of Mennig from focal depths was doomed to ascend, as having previously contributed to form one of the deepest portions of the basin of Neuwied. At length, however, as the lava in its ascent beneath the waters of the lake was extravasated, it would breadthen itself from the sides of the fissure in every direction, giving rise to a submerged lava field, which has varied in its width from one to two miles. The depth of the lava, in the site where it may be supposed to have issued from a deep longitudinal fissure, has never yet been estimated; but where, in laterally expanding itself, it has reached the margin of the lake, as in the vicinity of Obermennig, it may be found in the form of irregular prisms from ten to thirty feet high, covering the volcanic sand ejected by some previous eruption, probably that of the Hochstein.

After these conjectures, the limits of the lava field may be ascertained. It is bounded on the south and south-east by the meadow ground which we trace west of Obermennig, to a site intermediate to Thur and Frauenkirk, or about half a league east of the former place. From this site the easterly line may be carried due north, for perhaps half a league or more, until it meets the small hills which form the southerly boundary of the lake of Laach, along which its northerly limits are conducted. Its westerly line, which is a very irregular one, is formed by connecting a north-westerly point near the Laacher-see with a site where the lava is visible near Obermennig. Its extent I have before endeavoured to estimate. From north to south it may vary from one to two English miles, while from east to west it is about two miles.

* This phenomenon, owing to the comparative lateness of its date, must be reserved for the consideration of a future chapter. In the meantime I shall merely state, that the rent, which has divided the flow of Mennig into two parts, passes close to the town of Niedermennig, which is situated near the centre of the lava field. The ravine, thus formed, is now the channel for a small stream.

## SECTION II.—THE MINERALOGICAL CHARACTER OF THE LAVA.

With regard to the mineralogical character of this lava flow, it may be considered, as I have before remarked, intermediate to felspathose and basaltic rocks, or corresponding with the well known lava of Volvic in Auvergne, which has been named by Mr Scrope a greystone. I also presume that this is the same rock which M. Brongniart, under the title of a lava of Andernach rather than of Mennig, has named a *Tephrine Pavimenteuse*.

This lava has a base which is apparently homogeneous. It contains small cells or vacuities, which, along with its state of hardness and other qualities, conspire to render it pre-eminent as a millstone, for which purpose, indeed, ever since the time of the Romans, it has been quarried. Its colour is dark bluish-grey, and it is rough to the touch.

In its divisionary structure, it has been found to vary according to its depth. Thus the following section, which I have collected from the inquiries instituted by M. Steininger, will convey an idea of its different appearances, as we trace them in a descending order:

*(a.)* The uppermost bed, which has been described as composed of fragments of a black pumice stone. It perhaps merely consists of dark coloured cinders.

*(b.)* Hard porous stones, or rolled masses of lava, loosely lying upon each other. They are called *Mucken*. In thickness they amount to twelve feet.

*(c.)* Irregular colossal or perpendicular pillars which separate from each other, being from forty to eighty feet high. These are used as millstones. The millstone rock, again, sometimes passes into a softer argillaceous mandelstein mass, containing various included minerals. As we descend, the divisionary structure becomes less, until at length we arrive at

*(d.)* A mass in which the divisionary structure disappears. By M. Schulze this lowest bed has been named a reddish-grey porphyritic basalt. It is too difficult to be quarried for millstones, whence it has had the opprobrious title, given to it by miners, of Deilstein. Its depth is unknown.

The lava of Mennig is remarkable for the varieties of substances contained in it, of which repeated accounts have been given by mineralogists. In the history of the flow, it will be necessary to consider these as divisible into three classes, viz. 1*st*, into such mineral substances as have been broken from the walls of the fissure through which the lava has ascended, and, during its ascent, have been entangled in the substance of the lava; 2*dly*, into such adventitious substances as the lava during its escape, or extrava-

sation, has entangled; and, *3dly*, into such mineral products as may be regarded in the light of crystallisations, secretions, or infiltrations, resulting from the inherent chemical nature of the lava.

### 1*st*, *The Mineral substances broken from the walls of the fissure through which the Lava has escaped.*

The lava, in its ascent from the volcanic focus, has evidently, before reaching the surface of the ground, found an egress through a succession of rocks, of which granite may be considered as the first or lowest. To granite has succeeded in rotation gneiss, and afterwards clay-slate. Of the existence of intermediate strata of mica-slate, our evidence is not exactly determinate. Along with these rocks, the lava has evidently entangled in its mass fragments of subordinate rocks or strata, such as quartz and limestone.

The mineral substances thus resulting from the walls of the fissure through which the lava has ascended, I shall now consider in their order:

*(a.) Granite.*—In the lava near the town of Niedermennig, I found entangled in the lava the altered fragments of granitic rocks. One variety was composed of semicrystalline grains of felspar and quartz with little mica, but containing disseminated in it imperfect crystals of hornblende; a second variety, consisting of a whitish granite much altered by fire, contained no mica, and very few crystals of hornblende; while a third variety merely showed an intermixture of quartz and felspar. All these fragments had been so much reduced by heat, as at their margins to occasionally pass into the substance of the lava within which they were entangled.

*(b.) Gneiss.*—Fragments of a pale-coloured gneiss, evidently referable to the variety of granite which I have described in a stratified state, are discovered, though far less abundantly.

*(c.) Mica.*—Scales of mica are discovered entangled in the lava. One writer says they are abundantly intermixed with the lava, while M. Schulze has lately affirmed that the lava contains no mica. I must myself remark, that, although scales of mica may be detected, they rarely came under my observation. Whether they are referable to the disintegrated remains of strata of gneiss or mica-slate, through which the lava might have passed, I am unable to say.

*(d.) Clay-slate.*—That fragments of the rock of the district should be entangled in the lava is not remarkable, and needs no comment.

*(e.) Grauwacke.*—That grauwacke schist, which we may consider as forming the arenaceous strata incidental to transition rocks, should occur entangled in the lava of Mennig might be expected, although it has not come within my own observation. M. Schulze

mentions seeing an entangled sandstone formed of an aggregation of grains of quartzose sand, which has undergone a sort of swelling or tumefaction from the effects of heat. He describes it as of a colour sometimes whitish grey, or approaching to green; as harder than the millstone, and as blunting the tools of the miners.

*(f.) Limestone.*—Carbonates of lime have been occasionally found in the lava, which are not to be considered as the result of a process of infiltration, but as the entangled fragments of rocks of limestone, which, during the ascent of the lava, have been violently disengaged.

*(g.) Quartz.*—Fragments of entangled quartz prove that subordinate rocks of this substance have been pierced.

*(h.) Quartz containing Lead.*—I possess specimens of quartz containing galena, which show that the lava of Mennig has ascended through metalliferous rocks.

*(i.) Quartz containing the Sulphuret of Copper.*—An entangled specimen of this kind leads to the same conclusion.

*(k.) Schorl.*—M. Schulze mentions having seen schorl in the lava in a melted state. This is often an ingredient of granite.

*(l.) Iron.*—Fragments of oxidulated and magnetic iron have also been discovered in the lava.

These are all the substances entangled within the lava during its ascent which have come within my knowledge, or which I have been enabled to collect upon the authority of others.

*2dly, The Adventitious substances which the Lava during its extravasation has entangled.*

The adventitious substances which the lava appears to have entangled during its extravasation is confined to the trees which, at the time when the eruption occurred, appear to have grown upon the margin of the lake of Neuwied. Carbonized trees are said to have been found inclosed in the lava in an upright position, among which, it is stated, that a carbonized ash may be enumerated.

*3dly, The Mineral products, occurring as inherent Crystallisations, Secretions, or Infiltrations, which have resulted from the chemical nature of the Lava.*

The nature of the lava of Mennig has been before explained, (see page 121.) It is a substance intermediate to felspathose and basaltic rocks, to which geologists have been disposed to give the name of greystone. It has a base which is apparently homogeneous. It contains small cells or vacuities often lined with a variety of minerals. It is rough to the touch, and its colour is bluish-gray.

From the observations of various authors regarding the inherent crystallisations, secretions, or infiltrations, which have resulted from the lava of Mennig, I have drawn up the following list:

*(a.) Hauyne.*—This must be considered as a mineral substance very characteristic of the lava of Mennig. The form of its crystals is a dodecahedron; but it has been affirmed that perfect ones of this substance have not yet been found in the lava of Mennig. M. Von Leonhard states, that, in general, crystals of Hauyne are seldom found distinct, but with rounded edges.—Hauyne occurs in the form of large grains, some of which are said to be in portions of the size of hazel-nuts. Other characters are, that it has a vitreous lustre, with a colour which is often of a clear Berlin or smalt blue, sometimes cloudy, and not unfrequently green, gray, or even black; that it exhibits all the intermediate transitions from a translucent to a transparent character; and that it has a fracture, which, from being flatly conchoidal, passes into one which is uneven.

*(b.) Nephelin.*—A second substance, which, according to M. Schulze, is found in the lava, is Nephelin. This mineral is described in systematic works as occurring in drusy cavities in the clustered form of six-sided prisms encrusted over with a whitish or reddish substance. The foliated texture is more or less perfect, and the fracture is imperfectly conchoidal. It is diaphanous, with a colour which is chiefly greyish-white, or olive-green. Occasionally it is blue, brown, or even obscurely red.

*(c.) Titanite.*—This mineral, often named Spinellin, which occupies drusy cavities, occurs in the form of oblique rhombohedral prisms, frequently joined together lengthways in a tube-like form, and coated over with minute folia of chlorite. Titanite is of a hyacinth red, of a yellow, or greenish colour, with a dull glistening lustre, and a fracture imperfectly conchoidal, and even imperfectly granular. From being singly refractive, it passes to an undiaphanous state. In the lava of Mennig it is said to have been found in a *run* or vitrified condition.

*(d.) Porricin?*—Of this supposed new mineral we possess an imperfect knowledge. It forms the wall of druses, and commonly lines the nests of them. It has been named, from its external appearance, a capillary epidote. It is considered by M. De Wyck as a needle-formed augite. M. Steiuinger has described it as a mineral of a green colour, consisting of crystals of the finest needle form, and of a prismatic shape similar to that of pistacite or epidote. The name of Porricin has been given to it by Nose.

*(e.) Felspar.*—Glassy felspar occurs in grains filling up druses, also semi-opalescent felspar, as well as quartz hyaline.

*(f.) Augite.*—M. Von Leonhard states generally that this substance is a product of the Mennig lava. By other writers augite is said to be confined to the clayey mandelstein variety of the lava. M. Schulze has lately denied that there is any augite in the lava. My own observations certainly proved to me that there

was a substance to be found in granular particles through the mass, the crystalline form of which is lost, (probably by the intensity of the heat,) which could not be referred to any substance except augite, or hornblende. But it rather appeared to me as the former substance.

*(g.) Olivine.*—This is a rare ingredient of the Mennig lava.

*(h.) Leucite,* according to M. Schulze, has been found in the lava.

*(i.) Opal.*—Translucent grains like opal are said to occur in the lava, but they are confined by authors to the argillaceous mandelstein variety.

*(k.) Carbonate of Lime.*—A white and reddish white carbonate of lime has been found in the lava.

The list which has been given comprises, as far as I have been able to collect, all the minerals yet known, which may be considered as inherent crystallisations, secretions or infiltrations, with the exception of the calcareous tufa that is found in the clefts of the lava. As I consider that the presence of this substance is referable to a period which dates subsequently to the congelation of the lava flow, it will be noticed in an ensuing chapter.

These are all the particulars which I have been able to collect regarding the lava flow of Mennig. The interesting character of the subsequent beds by which it has been surmounted will be reserved for a future chapter.

## CHAPTER XIX.

### THE VOLCANOS BEARING EAST AND NORTH-EAST OF THE LAACHER-SEE.

From an investigation of the lava field of Mennig, we naturally recur to the Laacher-see, which may be considered as the great and common site of the volcanos of different dates. But, as I conceive that this central seat of convulsive operations will be more effectively described after certain other eruptions involved in its phenomena have been explained, an examination will be now made of the volcanos situated to the east and north-east of the lake of Laach. These are the Krufter-oven, the Rothenberg, and some few other volcanic peaks in their vicinity, together with the eruptions of Eich, and of the neighbourhood of Andernach, severally situated to the east of the Laacher-see; while to the north-

east, on the high ridge which bounds the Rhine, we find the volcanos of Fornich.

### 1st, *The Krufter-oven, the Rothenberg, &c.*

The Krufter-oven, which is the volcano nearest to the ridge which bounds the Laacher-see, may be found to the south-east of the same, while east of it is the contiguous volcano of the Rothenberg, variously named the Nickenisher Rothenberg, or the Roteberg.

It has been supposed by M. De Wyck that a regular crater has here subsisted, which, I suspect, is a mistake, as these two hills appear to have merely given out from small and obliterated apertures black volcanic sand, ashes, and blocks of slagged basalt, in which crystals of augite are contained. In fact, they are merely slag hills, such as I have explained, in which the quantity of aëriform fluids which have escaped from small apertures has been comparatively insignificant.

About half a league north of the Rothenberg, and due east of the Laacher-see, there appears to be one or more slag hills of precisely a similar character. The black volcanic sand and cinders given out in the course of these eruptions appear to have been washed into a lateral ravine, which, at a distance of three miles north, joins the trass valley of the Brühl. It must at the time have been in the state of a marsh, as we find that these volcanic ingredients were in some few places consolidated under water in the form of dark-coloured tufaceous strata.

### 2dly, *The Eruptions of Eich.*

Much more interesting than the last noticed eruptions are those near the village of Eich, which are situated still more east of the Laacher-see, and nearer to Andernach. They must have originally occurred on the very margin or shelving declivity of the lake of Neuwied, even when its waters were at a reduced level.

It has been supposed by M. De Wyck that a crater subsisted here, which later changes have rendered indistinct or almost obliterated. The site of it is said to be the deepening or cavity formed by the westerly flank of the Nastberg, and the hills severally named the Mittelsberg, the Hohewald, the Wohngerath, and the Breitelsbusch. From this supposed crater he has derived a flow of lava, the direction of which he has inferred more from the obscure indication afforded by the direction of its internal pores and vesicles, than from decisive appearances.

It is difficult to accede to this view. In my own survey of this vicinity, I saw far less the appearance of one large crater, than proofs that several distinct slag hills, or slag cones, together with a small flow of lava, had broken out on this site. From these slag hills much volcanic sand, rapilli, and blocks of a very porous and

scoriated basalt, of a bluish-black, and even of a brownish-red or tobacco colour, had been liberated. The Breitelsberg, for example, forms a striking cone of porous and scoriaceous fragments, below which appears the flow of lava.

The exact point of origin from which the lava stream may be supposed to have flowed is rather obscure, as it must have taken place from the very midst of an assemblage of slag eruptions. It has been most frequently referred to the Eicher Sattel. It evidently flowed into the lake of Neuwied, and became submerged beneath its waters, where it has afforded a basis for some interesting deposits remaining to be described in a later period of this history.

The lava of Eich, which is well studied in the Niesbusch stone-pits, where it is extensively quarried for millstones, has a character approaching to that of Mennig. It is a rock apparently intermediate to trachyte and basalt, resembling the greystone of Mr Scrope, or lava of Volvic, being of a dark bluish-grey colour, rough to the touch, and containing numerous small cells, and drusy cavities, which are lined with crystals, among which I particularly noticed the mysterious ones of Porricin, variously named capillary epidote, or needle-formed augite. Minute crystals of glassy felspar are also disseminated through the rock.

In the lava I found several entangled specimens of primary rocks, particularly of clay-slate, broken off from the walls of the fissure through which it had effected its escape. The most interesting of these was a beautiful white granite, in which there was a great excess of opalescent felspar. Whether the glistening lustre thus induced may be wholly or in part regarded as the effect of volcanic heat, I am not prepared to say.

The lava increases in compactness according to its depth. An upper portion, about 15 to 18 feet in thickness, is very much slagged or burnt, under which I found a more compact mass, about eight yards of which had then been quarried;—but the depth of it is unknown. In the upper portion of the lava may be observed slight infiltrations of calcareous spar.

This description will probably serve for the eruptions of Eich. The volcanic ashes washed into the lake of Neuwied, as well as into the valley situated to the north of the hills of Eich, which I shall name the valley of Kehl, appear to have formed tufaceous deposits.—To these I shall advert hereafter.

*3dly, The Eruptions situated a little to the south of Andernach, near St Thomas's Convent, and the Hach Mills.*

This very obscure eruption of scorified basalt appears but a few feet above the surface of the ground from amidst a much later superjacent deposit of loose fragments of white pumice, beneath

which it is nearly concealed. It may be observed a little distance, perhaps not more than half a mile, south by west of the late convent of St Thomas, now converted into a tannery. Whether it is to be regarded as indicative of a small lava stream, I am scarcely justified in forming an opinion.

Another eruption, equally obscure, is to be inferred from the isolated fragments of scorified basalt which we find about an English mile south of St Thomas's convent, near the source of a copious spring of fresh water which supplies the city of Andernach. The place is named, from the mills which it sets in motion, the Hach-Mills.

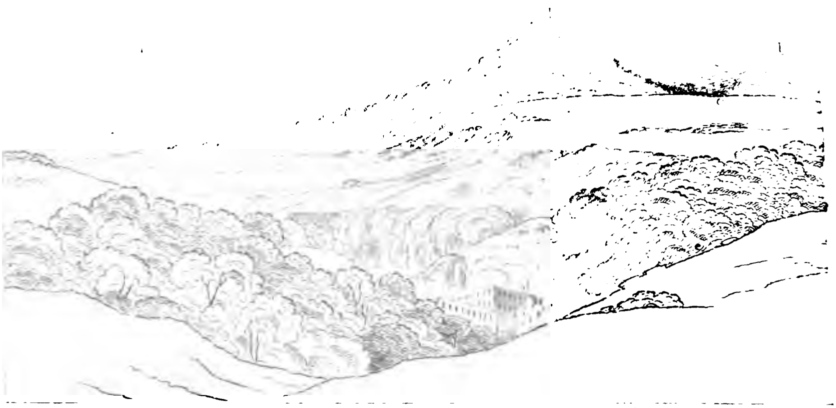
*4thly, The Eruptions above the Village of Fornich on the Rhine.*

In tracing the high ridge which forms the left bank of the Rhine for the distance of a league or more north-west of Andernach, we fall in with a very wooded hill, which is, I believe, named the Wahsbusher Kopf, from which a small eruption has taken place. It may be described as situated at the distance of nearly a league and a half north by east from the Laacher-see.

This volcanic peak, which is chiefly formed of heaped up blocks of a porous, yet hard basalt of a light bluish-grey colour, in which numerous crystals of augite are interspersed, derives its chief interest from having taken place at a period when the channel of the Rhine, north of the gorge of Andernach, had been so deeply fissured by the conjoint operation of sudden violence and more gradual causes of corrosion, as to show a level of waters differing perhaps little from what it maintains at the present day. This is evident from a trifling flow of lava, which, in descending down a steep declivity into the deep channel of the Rhine, may be observed to have found a lodgement at an elevation nearly the same as that of the present level of the river.

It ought, however, to be added, that, if the Rhine itself at the close of the tertiary epoch was maintaining a very low elevation, the lake of Neuwied, though greatly reduced in its level, was in an incomplete state of drainage. Consequently, between the gorge of Andernach and the present site of the village of Fornich, there must have subsisted a considerable discharge of waters in the form of a cataract.

But besides the Wahsbusher Kopf, there is another small eminence in its immediate vicinity, which, I believe, bears the name of Alkenhof. The scoriated basalt which is there found gives similar evidence of a very insignificant flow of lava.



b ... c ... Dammerfeld

a Situation of ... b The ... c The ...
d d Hassenach e e The ... Valley of the ... f f The upper Valley of the ...

... M. Hebert

The Abbey [illegible] Valley of the [illegible]

Trass Deposit. Valley of Brohl.

Etched by W. [illegible]

## CHAPTER XX.

### THE VOLCANOS CONNECTED WITH THE TRASS VALLEY OF THE BRUHL.

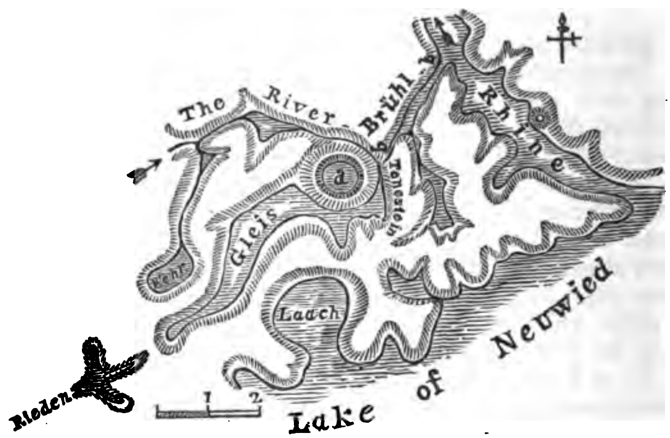
It will be necessary for me to preface this chapter with a descriptive account of the original site of the volcanos connected with the trass valley of the Bruhl.

At the commencement of the tertiary period, an irregular lake had subsisted along the course of the river Bruhl from its source near the present site of Hahnenbach to Burg Bruhl; but owing to the early eruptions of the Perlenkopf, and of the craters of Fusel and Wehr, the greater part of the lake appears to have been subsequently filled with tufaceous and other volcanic products. The overflow from this lake was between the present site of Burg Bruhl and that of Tonistein, where it flowed down a precipitous channel into a deep fissure that met it at nearly right angles. This I have already supposed (page 23,) to have been a valley of disruption extending from Wassenach to the Rhine,—a distance of five miles, which was perhaps produced by the strain occasioned during the first disengagement of elastic fluids from the central aperture of Laach. It is remarkable for its precipitous banks, and for the salient and re-entering angles which mark its course, severally indicative of a violent origin. In contradistinction to the higher portion of the Bruhl west of Tonistein, it may be named *The Trass Valley of the Brühl*, on account of being in part filled with a tufaceous mud, or moya, commonly named *Tuffstein*, which, after having been quarried, is subjected in large mills to the progress of grinding, and in this pulverised state is known in commerce by the name of *Trass*. This tuffstein has resulted from the volcanos which are the subject of the present investigation.—(*See Plate VII.* where the course of the trass valley of the Bruhl may be traced in views 1st and 2d by the letter *e.*)

The geographical situation of the Trass valley of the Bruhl having been described, we may next recur to the ancient lake of Gleis, which, as I have stated, (page 49,) had received a large share of the overflowings of boiling mud discharged from the volcanic cauldron of Rieden. It has been considered as a deep narrow ravine about five English miles in length, and varying in its breadth from a quarter of a mile to a mile and a quarter, having been bounded on the west by the high banks contiguous to the basin of Wehr, on the east by a clay-slate ridge of the Laachersee, and on the north and north-east by a circular hill, the site of subsequent volcanos, to which the name of the Lummerfeld is now given. The height of this eminence was originally inconsi-

derable. Its southerly flank was washed by the waters of the lake, which, in making a sweep to the east, discharged themselves into the Trass valley of the Bruhl.

Such was the original state of the Lummerfeld, when all the volcanos connected with the deposition of the tufaceous mud or tuffstein into the Trass valley of the Bruhl became in turns manifested. A geographical illustration of the district at the close of the tertiary period is intended to be represented in the following plan:




*English Miles.*

The letter *a* indicates the crater of the Lummerfeld, which subsequently became a crater lake.

The letters *b b*, the trass valley of the Bruhl.

The volcanos connected with the trass valley of the Bruhl are among the most interesting ones in the present district, yet, from their complication, they are perhaps the most difficult to investigate. Their brief history appears as follows:

1*st*, The site of the volcanic explosion was a small eminence to the north of the tertiary lake of Gleis, named the Lummerfeld, where a crater broke out, which may be named, in distinction, the crater of the Lummerfeld.

2*dly*, This crater, owing to the water which found admission into it from the lake of Gleis, became the site of a crater-lake.

3*dly*, This crater-lake, during the continuance of the volcanic action, became filled with tufaceous mud, or moya.

4*thly*, A newer and lesser crater, namely, that of the Kunkskopfe, broke out on the site of the crater of Lummerfeld.

*5thly*, A consequent displacement of the volume of the moya, or tufaceous mud, ensued, which was followed by its overflow into the adjoining valley of the Bruhl.

*6thly*, A new crater-lake was wholly, or in part, formed by the walls of the crater of the Kunkskopfe.

*7thly*, During the continuance of the eruption of the Kunkskopfe a fresh accumulation of moya, or tufaceous mud, ensued.

*8thly*, Still newer volcanic eruptions, characterized by flows of basaltic lava, supervened.

*9thly*, As an effect of them, a later displacement occurred of the volume of the fresh accumulation of moya, or tufaceous mud, which again burst its barrier, and again overflowed into the trass valley of the Brühl.

*10thly*, As a consequence of this upfilling of the trass valley of the Bruhl, a blockade, or damming up, ensued of the waters which issued from the upper and lateral valley of the Bruhl, between Hahnenbach and Burg Bruhl, so as to reconvert this upper valley into the form of a lake.

*11thly*, From a similar cause a damming up took place of the lateral valley of the Kehl, which was thereby converted into the state of a small lake; while

*Lastly*, during the course of these eruptions, saline springs and gaseous exhalations burst forth from many parts of the trass valley of the Bruhl, as well as from the depths of the lateral vallies connected with it.

Having thus explained the general routine of volcanic phenomena which the craters connected with the Brühl have presented, the plan which appears to me the best adapted to an investigation of them in detail, is to pursue the order of inquiry which this historical summary has suggested.

### SECTION I.—THE BREAKING OUT OF THE CRATER OF THE LUMMERFELD.

The breaking out of the crater of the Lummerfeld has a date which is probably much later than that of the Herschenberg, or of the Bausenberg, described in the twelfth chapter, which appear on the opposite side of the Bruhl.

There is little to remark concerning this crater more than relates to its original magnitude, some notion of which may be obtained from the segment of its walls observable on the northerly side of the Lummerfeld. Its diameter could have been scarcely less than a mile. Its walls, which, from subsequent convulsions, now appear elevated but a little above the soil, were composed of dark volcanic sand, cinders, and fragments of basalt slag of a reddish black colour, in which crystals of augite are contained.

### Section II.—The conversion of the Crater of the Lummerfeld into a crater lake.

When it is considered that the southerly flank of the Lummerfeld rose abruptly from the very deep waters of the lake of Gleis, and that a large crater occupied the whole of the eminence even to the very brink of the lake, it is to be presumed, that by volcanic convulsions some rents might have occurred, by which lacustrine waters would find admission into the depths of the crater. That such a catastrophe actually took place, we are assured by collateral evidence, which is irresistible. But it is not so easy to determine whether the lake induced was an open one, or whether it did not rather occupy a sort of subterranean cavity roofed over by the demolished or sunken in walls of the crater, such as can be shewn to have subsisted within the crater of Vesuvius, prior to the mud eruption by which the city of Herculaneum was enveloped.

But the solution of this question is a subordinate one, as nearly similar effects, whether from an open or subterranean crater lake, would ensue.

Upon the presumption that the crater-lake of the Lummerfeld, which must have originally subsisted in a state of ebullition, was an open one, which is perhaps the least difficult supposition of the two, an ideal representation of its original state has been attempted in the geographical plan given in a preceding page. (P. 130.)

### Section III.—The tufaceous mud with which the crater of the Lummerfeld became filled during the continuance of the volcanic action.

We are assured, from the ingredients which have entered into the composition of the lower beds of the tuffstein of Bruhl, that during the continuance of the volcanic action of the Lummerfeld, pumiceous particles were ejected. These must be regarded as nothing more than basaltic materials, reduced by the continued and increased agency of heat to this very light and fibrous state. They differ from those resulting from trachytic or felspathose ingredients in the darkness of their colour, indicative of their basaltic origin. They appear in general to have been very small, the largest scarcely exceeding in dimensions the fourth of an inch, while the smaller are so minute as to assume the character of pulverulent particles.

The quantity of light volcanic materials ejected by the crater of the Lummerfeld must have been so great, that, if they had been discharged high in the air, they would doubtless have covered a considerable tract of country. But different circumstances having intervened, we must consider these particles as having been given out from a volcanic focus, which subsisted beneath the waters of a crater-lake. In this case, as I have before observed, the waters of

the lake would intercept all the light pumiceous or pulverulent particles ejected in a state of incandescence, whence would result a crater filled with boiling mud, or moya.

The quantity of tufaceous mud would again be increased by the decomposing action which water at an elevated temperature would possess, but more particularly when assisted by the various soluble products emitted from the volcanic focus, by which a still stronger chemical energy would be imparted to its constitution. Hence the occasional effects which may be traced in the tuffstein of Bruhl from the decomposition of less levigated substances ejected by the volcano, such, for instance, as black volcanic sand, or rapilli.

But this decomposing effect of the boiling liquid is the most powerfully indicated in the apparent action which it has exerted upon the thin partition of clay-slate, by which the crater of the Lummerfeld is separated from the deep bed of the trass valley of the Bruhl. This is observable in the ridge above the present site of Tonistein, where we find that the clay-slate is for a considerable thickness decomposed, and often transmuted into a substance approaching in its colour and other qualities so nearly to that of plastic clay, that it is chiefly to be distinguished from this substance by the greater cohesion which has remained of its component particles. As a consequence, the thin barrier which intervened between the crater of the Lummerfeld and the ravine of the Brühl has been so deprived of its firmness and solidity, as to become the breach, by which, during a subsequent convulsion, volcanic mud was enabled to escape and overflow into the trass valley of the Bruhl.

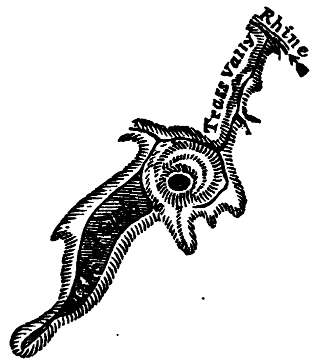
## Section IV.—The newer and lesser crater of the Kunkskopfe, which broke out within the crater walls of the Lummerfeld.

After the crater lake of the Lummerfeld had been filled with boiling mud, a new volcano burst forth. Elastic gases were liberated in considerable volumes, and along with them scoriated fragments of basalt in the form of ashes and large blocks.

This later explosion gave rise to the crater of the Kunkskopfe, the original diameter of which was less than that of the Lummerfeld, amounting to scarcely half the extent. It encroached upon the southerly limits of the former crater, as may be shown in the sketch on the next page.

The walls of the Kunkskopfe, which appear far higher than those of the Lummerfeld, are composed of, *1st*, large masses of basalt slag, of a bluish-black, as well as of a tobacco-brown colour, varying in their degrees of shade, in which I could detect few crystals of augite; *2dly*, of rapilli or cinders of a yellowish-brown

tint; *3dly*, of volcanic sand and ashes; and *4thly*, of fragments of clay-slate much altered by heat. The interior declivity of the crater walls is very steep, and the summit of them is narrow. *




SECTION V.—THE DISPLACEMENT WHICH TOOK PLACE, COINCIDENT WITH THE ERUPTION OF THE KUNKSKOPFE, OF THE VOLUME OF THE TUFACEOUS MUD, OR MOYA, CONTAINED WITHIN THE CRATER LAKE OF THE LUMMERFELD, WHICH WAS FOLLOWED BY ITS OVERFLOW INTO THE ADJOINING TRASS VALLEY OF THE BRUHL.

The effects which appear to have more immediately resulted from the newer crater of the Kunkskopfe bursting forth within the limits of the older one, consisted in the displacement which ensued of the volume of tufaceous mud contained within the crater-lake of the Lummerfeld, and in the extravasation of the same mud or moya into the adjoining trass valley of the Brühl.

The relative situation of the crater of the Kunkskopfe, and that of the valley of the Brühl, is readily seen in the view which has been given.—*(See plate VII.* page 129.*)*

The particular part of the crater walls of the Lummerfeld which would most favour the escape of the displaced volume of the moya, has been already explained. It would be that thin portion, consisting of clay-slate in a half-decomposed state, which, above the present site of Tonistein, intervened between the crater and the deep ravine of the Brühl. Here a breach was formed, from an examination of which we learn, that the eruption of the moya into the valley of the Brühl was an instantaneous one. The impetuosity with which this result took place is indicated by the shattered state of the frail walls which vainly opposed an obstacle to

* Half of their extent is entire. It is on their northerly side that they have suffered much demolition. *(See plate VII. view 1st, where a representation appears of the crater of the Kunkskopfe.)*

the sudden rush which ensued of the extravasated mud, in its descent within the deep ravine of the Brühl, which it filled to a considerable depth.

The moya which was extravasated on this occasion must be sought for in a lower deposit of the tuffstein of the Brühl. The superior portion of the mass is the result of a later disturbance, which will be described hereafter.

The base of the earlier deposit of tuffstein is composed of pulverulent particles, which are evidently derived, as their more dark or bluish-black colour would intimate, from materials of basalt altered by intense heat. Contained in this base are small portions of pumice, of a paler colour, which appear in abundant diffusion. Rapilli may also be found in the tuffstein, particularly near the mill of Tonistein, of a bluish-black or reddish-brown colour, along with small and shattered fragments of clay-slate.

It is not a little remarkable that the tuffstein of Brühl closely resembles in quality the "liquid mud" (as Sir William Hamilton calls it) generated in the interior of Vesuvius, no doubt within a subterranean crater lake, which, prior to the eruption of the year 79, enveloped and entombed the ancient city of Herculaneum. This resemblance, indeed, might have been anticipated, as the eruptions of Vesuvius at that time must have agreed with those of the Lummerfeld, in having been derived from basaltic materials which had undergone the necessary modifications from fire. We may also anticipate, that the tufa of Bruhl, when first ejected from the crater lake of the Lummerfeld, would, like the mud eruption of Vesuvius, harden in a few days, which (as I have before remarked) required, even in that short interval, for the breaking of it the assistance of picks. Hence the total want of stratification exhibited by the tuffstein of Bruhl.

This deposit has been suspected to contain some adventitious substance in its composition, by which it is rendered less hard and more porous than the ovenstone of Bell, which has a similar origin. The nature of this additional matter it may be difficult to point out. Probably, owing to the contiguity of the crater of the Lummerfeld to the bed of the lake of Gleis, its contained moya might have been, in some trifling degree, intermingled with the deposit of these waters, which has consisted, as I have before observed, of fine tufaceous particles derived from the crater of Rieden, and blended with lacustrine sand and clay.

But one of the most interesting characteristics of the tuffstein is yet to be explained.—Remains of trees are contained in it, such as still characterize our forests, the progenitors of which are no doubt to be identified in the trees of the brown coal formation. *

* Mr M'Nab, of the Royal Botanic Garden, Edinburgh, to whose judgment I submitted the most perfect fossil leaf in my possession, refers it to the *Populus tremula*.

They must have flourished as well in the valley of the Bruhl, as on the borders of the crater lake whence the extravasation of moya ensued.

It has been remarked by more than one geologist, that the mode in which these trees have been entangled indicates great force or power. In the case of such as are supposed, from the erect position in which they are found, to have previously existed in the valley of the Bruhl, only the lower parts of the heavy stems have been found *in situ;* the removed branches having been broken off in the direction of the valley, or, in other words, in the direction which the moving mass of the moya took in its descent towards the Rhine.

The carbonization of the wood inclosed in the tufa is often complete, indicative, it is supposed, of the exceeding heat of the fluid mass in which it was involved;—though, perhaps, regarding this inference some doubt may be entertained, as excessive heat is not essential to carbonization. On the other hand it is remarked, that in some cases the scattered leaves of imbedded trees seem either more carbonized on one side than the other, or are only carbonized on a single side; while in other instances, both wood and leaves appear perfectly uncarbonized; the finer parts having undergone a sort of change from infiltration, which could not have taken place by the action of fire.

After this eruption of moya had ensued, attended with a complete discharge of the contents of the crater lake, a projection of volcanic matter into the open air appears to have been the next result, which, in falling, has covered over the extravasated deposit of Brühl with a layer of rapilli two inches in thickness, which at present serves to divide the lower erupted mass of tuffstein from a later one. It is a little remarkable that these rapilli are coated over with a brown hydroxide of iron, which might have resulted from the ascent or diffusion of acid vapours given out by the volcanic mud;—a phenomenon which I shall consider in a succeeding section. This layer of rapilli is particularly exposed at a site named Eulenkeule, above Tonistein.

### Section VI.—The new crater Lake which was formed.

After the appearance of the newer crater of the Kunkskopfe, the limits of the crater lake would undergo a modified construction. They would no doubt be wholly or in part formed by the newer walls of the crater of the Kunkskopfe. This is well shewn in Plate VII. 2d view, p. 129.

### Section VII.—The fresh accumulation of Tufaceous Mud, or Moya, which, during the continuance of the volcanic action, ensued.

It was during a continuance of the volcanic action of the Kunks-

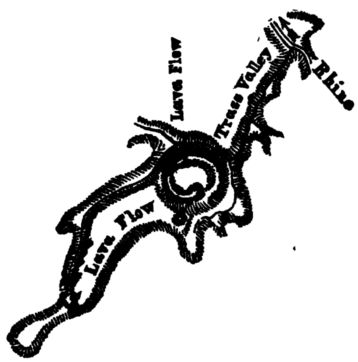
kopfe, that a second upfilling occurred of the same crater lake. Pulverulent matter, along with an increased proportion of pumiceous particles, continued to be elaborated within the volcanic focus, which, having been intercepted by the waters of the basin, formed with them a renewed volume of tufaceous mud, which chiefly differed from the former one in the pulverulent matter, or pumice, having been of a paler colour, owing, probably, to a prolonged action of heat.

SECTION VIII.—THE STILL NEWER VOLCANIC ERUPTIONS, CHARACTERIZED BY FLOWS OF BASALTIC LAVA, WHICH SUPERVENED.

To the breaking out of a second crater and the upfilling of the crater lake with renewed contents of moya, succeeded still other eruptions, characterized by two flows of basaltic lava.

The first of these we trace from the south of the crater of the Kunkskopfe into the tertiary lake of Gleis, which it must have filled; while the second, or far lesser one, had its origin within the northerly limits of the Lummerfeld crater, the walls of which, in flowing into the valley of Burg Brühl, it has broken.

These eruptions are represented in the following plan:




*(a.) The greater Lava Flow which we trace from the south of the Kunkskopfe into the valley of Gleis.*

The larger flow of lava may be traced to a point of origin south of the volcanic hill of the Kunkskopfe, being below the highest part of its crater walls which were unaffected by the eruption.

The lava consisted of a dark coloured basalt containing augite, which was much scorified.

It appears to have directed its course towards the lake of Gleis,

the bed of which it has occupied for a distance of two miles, expanding in width until it approached the side of a southerly clay-slate ridge, against which it strove to form an abutment. But this contact was prevented by the quantity of mud mixed with volcanic products which the lava stream in its progress had displaced, and which filled the intervening space between the clay-slate hills and the lava stream, so as to stop one of the outlets of the lake by damming up a stream which discharged itself in the westerly valley of the Brühl, near to the present site of Burg Brühl.

The mud which was thus disturbed appears to have been a coarse mixture of clay, volcanic ashes, and cinders, much of which has been removed during the course of time by the gradual drainage of the ancient lake. It may be traced from the village of Gleis to Burg Brühl.

The water which was displaced during the occupation of the bed of the lake by so large a mass of lava, must have readily found a discharge through the channel of the trass valley of the Brühl into the Rhine. Whether its effects can be traced in the removal of any portion of the substance of the tuffstein, over which it must have flowed with some degree of violence, I am unable to state.

(*b.*) *The lesser eruption of basalt, which, in taking place from the interior of the crater of the Lummerfeld, intersected its northerly walls.*

There are evident marks of a basaltic eruption which took place within the crater of the Lummerfeld, and which may even be suspected to have extended its influence to the Kunkskopfe, so as probably to have effected the demolition of the northerly walls of its crater. This breach is represented in the delineation of the crater which has been given. (*See Plate VII.* page 129.)

This eruption appears to have taken place in the form of one or more dikes of unscorified basalt, (resembling an older basalt,) through which crystals of augite as well as olivine are diffused.

The dike appears to have intersected the northerly walls of the Lummerfeld crater, while an overflowing from it took the direction of the valley near the site of the church of Burg Brühl.

[But besides these two flows of lava, another eruption has been recorded. M. De Wyck states, that opposite to the Tonistein trass mills, upon a declivity of the slate mountains of the Kreuzberge, is an isolated basaltic rock named the Tauber. This volcano escaped my notice. Its relations are said to be unknown.]

SECTION IX.—THE EFFECT OF AN ERUPTION OF BASALTIC LAVA IN BREAKING UP THE VOLCANIC BASIN FILLED WITH BOILING MUD, AND CAUSING A SECOND OVERFLOW INTO THE TRASS VALLEY OF THE BRUHL.

The larger flow of lava which had its origin in a point of eruption south of the Kunkskopfe had probably little effect in producing this catastrophe.

It is (as I have observed) to the invasion of the interior of the crater of Lummerfeld by basaltic lava that we must attribute the demolition of the northerly wall of the crater of the Kunkskopfe, (*see Plate VII.* page 129,) as well as the breaking up of the volcanic basin filled with moya.

The mud in its descent must have again effected its escape through the breach of the crater walls above the present site of the village of Tonistein, where strata of clay-slate, half-converted by the chemical action of the boiling mass into the substance of a white clay, exhibit a most remarkable example of dislocation and destruction.

The result was, that, by two successive eruptions, the ravine of the Brühl was filled for a distance of three miles, until it joined the valley of the Rhine with a deposit of tuffstein, to the depth of 120 feet.

The upper or later overflow is readily distinguished from the older one by the comparative lightness of its colour. The lower beds, when first quarried, appear very dark, but, upon exposure to the sun, or after desiccation, grow paler.

In the use to which these beds are severally applied a difference is also experienced. The bluish-grey kind, as the lower beds are called, is said, when pulverized, to harden the quickest under water, but above water to be too friable for use; its place under these last mentioned circumstances being better supplied by the upper or yellowish-grey variety, which, if less applicable to hydraulic purposes, does not above water dry so quickly.

SECTION X.—THE RECONVERSION OF THE UPPER AND LATERAL VALLEY OF THE BRUHL, FROM HAHNENBACH TO BURG BRUHL, INTO A LAKE.

Several subordinate effects appear to have resulted from the upfilling of the trass valley of the Brühl with a mass of tuffstein.

One of these was the damming up of currents in their course through the upper lateral valley of the Brühl, from Hahnenbach to Burg Brühl, and the reconversion of this valley into the bed of a lake.

To explain this effect, we must recur to what has been before stated in reference to the earlier character of the upper valley of the Brühl, from Hahnenbach to Burg Brühl.

Near the present site of Burg Brühl a barrier of rock had originally subsisted, by which much of the district west of it had long been in the state of a lake or morass; but this barrier having been in process of time worn down nearly to its present level, a communication had been at length formed with its easterly waters, and with those which descended through the proper trass valley of the Brühl from the heights north of the Laacher-see to the Rhine.

Under these previous circumstances the upper channel of the Bruhl formed a sort of lateral valley, which met the proper trass valley of the Bruhl at nearly right angles.* Consequently, when the upfilling of the trass valley with the moya brought down from the Lummerfeld ensued, the result would be, that this upper and lateral channel of the Bruhl, from Hahnenbach to Burg Bruhl, would be dammed up, and once more reconverted into the form of an irregular lake. A very slight view of the general map, or of Plate VII. 2d view, will elucidate this event.

This upper valley shews much evidence of the ancient blockade of its waters, in the singularly conglomerated state of the fragments of clay-slate, of trachytic tufa or of basalt, which have been conveyed by torrents to the site where the junction of the two valleys commences. This is well exhibited near the mill of Burg Bruhl.

### Section XI.—The damming up which the lateral ravine of Kehl experienced from the upfilling of the Trass Valley of the Bruhl, and its conversion into the state of a lake.

Another incident, similar to the last described, appears to have resulted from the upfilling of the trass valley of the Bruhl. This was the damming up of the lateral ravine of Kehl.

The lateral valley of Kehl has its source a little to the north or north-east of the Nastburg near Eich. It is a deep ravine five miles in length, where the waters collected in it were drained off in a northerly direction, and discharged a little to the north of the village of Kehl into the trass valley of the Bruhl.

From an inspection of the general map it is evident, that, upon the trass valley of the Bruhl becoming filled with tuffstein, the ravine of Kehl would assume the form of a small lake.

While the valley of Kehl was in this state, it would appear that the volcanos of Eich were in activity, and that the lighter ashes given out from these eruptions had in part fallen into it, where, in mingling with its waters, they had been accumulated in various sites in the form of a tufaceous deposit. (See page 127.)

* This relative situation is well shewn in the smaller view represented in Plate VII. page 129, where the upper and lateral valley of the Bruhl is marked *ff*.

## SECTION XII.—THE SALINE SPRINGS AND GASEOUS EXHALATIONS WHICH BURST FORTH FROM MANY PARTS OF THE TRASS VALLEY OF THE BRUHL, AS WELL AS FROM THE DEPTHS OF THE LATERAL VALLIES CONNECTED WITH IT.

Within the depths of the trass valley of the Bruhl there are abundant proofs of numerous calcareous springs having long existed, more particularly at the time when it became filled with the mud eruptions from the Lummerfeld. This will be shewn when I have to describe in a future chapter the travertine which in many sites replaced the removed beds of tuffstein. A remarkable spring of this kind exists at the present day, namely that of Tonistein, celebrated in many parts of Germany for the quantity of carbonic acid gas evolved by it, which, according to an experiment made, is at the rate of 100 cubic inches of gas for 100 cubic inches of water. But this estimate is said to be much too low. From five pounds of this water, M. Funke obtained by evaporation $90\frac{1}{4}$ grains of solid matter, consisting of 45 grains of carbonate of lime, $36\frac{1}{4}$ grains of carbonate of soda, a quarter of a grain of the carbonate of iron, $4\frac{3}{4}$ grains of the muriate of soda, and 4 grains of the sulphate of soda. (*Harless, die Gesundbrunnen am Niederrhein*, &c. p. 60 to 70, &c.)

It is no doubt due in a great degree to the infiltrated matter which has been imparted by these springs to the tuffstein of the valley of the Bruhl, that we find the carbonate of lime entering into its analysis. A hundred parts of the tuffstein, (it is not stated whether from the lower or upper beds of the valley,) are said to have consisted of 55 to 57 parts of siliceous earth; 27 to 28 of aluminous earth; 8 to $8\frac{1}{2}$ parts of ferruginous matter; and, along with these ingredients, of 6 to $6\frac{1}{2}$ parts of the carbonate of lime.

It is owing most probably to these springs, or to independent gaseous exhalations coincident with volcanic phenomena, that we are indebted for the discoloration, which in many places is evident, of the tuffstein, and particularly of the pumice contained in it, also for the saline matters which, in the form of efflorescences, are observed to still exude. A salt procured from the quarries of Bruhl was found to contain sulphate of alumina, magnesia, muriatic acid, a very small proportion of alkaline matter, and oxide of iron. And, in another analysis, the following result was obtained:

| | |
|---|---|
| Sulphuric acid free from water, | 8.682 |
| Muriatic acid, - - | 6.714 |
| Carbonic acid, - - | 20.837 |
| Potash and soda, - - | 63.767 |
| | 100.000 * |

* *Das Gebirge Rheinland Westphalen*, Vol. iv. p. 238.

Such are the effects which have apparently been produced in the trass valley of the Bruhl from its saline springs and gaseous exhalations. Nor less remarkable are those of the lateral valley of Kehl, which I shall next consider.

In the lateral valley of Kehl, which was dammed up by the upfilling of the tuffstein, saline springs and gaseous exhalations appear to have played a no less important part than in the main valley of the Bruhl.

The valley of Kehl, in the geological phenomena which it exhibits, is entitled to a more particular investigation than I had then time to devote to it. In examining its bounding ridges of clay-slate, I found that a decomposition of the strata had in many places ensued to such an extent, as to convert them to a pale yellowish-coloured mass of exceeding softness and friability, approaching to the character of the plastic clay deposit of the basin of Neuwied.

This most remarkable effect I have been inclined to attribute to the chemical properties with which the waters of the valley of Kehl were endowed, while they were dammed up and confined. Thus, if it be assumed that springs like those of Tonistein must have very early subsisted in this valley, we may reasonably infer that powerful energetic effects would be imparted to the waters of this small lake, assisted probably by gaseous exhalations which so frequently accompany the violence of volcanic actions.

That this speculation meets with every support from existing appearances, I shall now endeavour to show.

In the valley of Kehl saline springs may be detected, no less powerful than those of the trass valley of the Brühl. Thus, the Heilbrunner well, near Kehl, which is distinguished for the milky deposit which it yields, likewise gives out carbonic acid gas, though not in such a quantity as the spring of Tonistein. From 100 cubic inches of the water, 60 cubic inches of gas were obtained. The saline ingredients obtained by evaporation from this fountain are remarkable. From five pounds of water 143 grains were collected, which consisted of carbonate of soda 54 grains; of sulphate of soda $6\frac{1}{2}$ grains; of muriate of soda 24 grains; of carbonate of lime $55\frac{1}{2}$ grains; of carbonate of magnesia 2 grains; and of carbonate of iron 1 grain.

That pure gaseous exhalations might have likewise taken place from deep clefts or fissures in the valley of Kehl, is countenanced by the phenomena presented in the trass valley of Brühl. The saline efflorescences exposed in tuffstein quarries evidently point to exhalations of sulphuric, muriatic, or carbonic acids, with which the alkalis are combined. These might have been going on while the ravine of Kehl was filled with water, and thus have contribut-

-ed to produce the chemical effects which its schistose rocks of clay-slate so strikingly exhibit;—effects which are well calculated to throw light upon many circumstances connected with the origin of such older tertiary strata as were deposited, when volcanos far more numerous than those of historic times were in an extreme state of activity.

This last view which I have taken meets with support in another appearance which is presented by the valley of Kehl.

In one locality I found that the same decomposed strata of clay-slate had undergone a change of colour from some adventitious matter resembling plumbago, by which they were very thinly coated over and blackened. At the same time my surprise was increased to find, that they were not only warped and hardened, as by the heat of a furnace, but that in a few places a sort of conglomerate rock had been formed by very small shattered fragments of clay-slate thus coated over, and afterwards, either by chemical means or by volcanic heat, firmly agglutinated.

To account for this appearance I searched for some unequivocal indication of volcanic fires, in the absence of which I am strongly inclined to suspect that phenomena had taken place in the valley of Kehl, somewhat analogous to what I have observed in the vicinity of Modena, consisting in the evolution of gases from very trifling apertures no larger than those of common wells. At the same time it must be added, that, in the valley of Kehl, these gases must have risen with a force capable of shattering the strata which offered a resistance to their escape;—and, as it is possible that the same gases were also capable of being inflamed upon coming in contact with the atmosphere, we are perhaps warranted in attributing to this cause the slight marks of heat, which seem to have contributed to the subsequent agglutination of the dispersed fragments of clay-slate. The coating, resembling plumbago, with which these fragments are blackened, appears to be a carburet of iron;—though in one specimen I observed faint indications of the presence of the sulphuret of iron.

Lastly, in the lateral valley of the Brühl, between Hahnenbach and Burg Brühl, many saline springs and gaseous exhalations appear no less to have burst forth, though their effects upon the strata which came under their influence are not to be so easily traced. Mineral wells, nearly similar to those of Tonistein, are found at Ober and Nieder Zissen, and near Burg Brühl.

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These are all the volcanic phenomena connected with the trass valley of the Brühl which I have been enabled to collect. The

inquiry into them has been a difficult one, upon which no prior treatises that I have consulted throw any important light. M. Steininger is the only geologist who has suspected that the eruption of the tuffstein came from the Kunkskopfe; but he has offered for his opinion scarcely any details, and no proofs whatever.

Any further information regarding the trass valley of the Bruhl belongs to a future period of our history, which cannot be conveniently anticipated. For the present, therefore, the following brief observations may suffice:

The tuffstein, which, in its prompt consolidation, had blocked up two lateral vallies, and had caused corresponding lakes to ensue, began to soon give way to the corroding effects of mountain torrents.

The waste ensuing from this cause, although a gradual one, was, by the softness of the materials acted upon, rendered tolerably rapid; eventually producing immense insulated masses of tuffstein, which, in having survived the undermining action of the Bruhl, now, under the most picturesque forms, line its wooded heights. *(See Plate VII.* p 129, 3d *view.)*

## CHAPTER XXI.

### THE REVIVED, OR COMMENCING, ACTIVITY OF SUCH VOLCANOS, AS HAVE CONTINUED THEIR ENERGY TO THE CLOSE, OR EVEN BEYOND IT, OF THE TERTIARY EPOCH.

I HAVE deferred to the latest investigation such volcanos as have exhibited an activity which has extended itself to the close, or even beyond it, of the tertiary epoch.

The volcanos which fall under this description are referable to two localities; the first of which is the Laacher-see, while the latter is the vicinity of the hills named the Humrichs, situated near the confluence of the Nette and the Rhine.

The revived eruptions of the Laacher-see certainly date from the time when many other large volcanos, which I have recently described, were in activity. But, in the continuance of their operations, they long survived the suppression of such other volcanos, and did not cease to be inactive until the close of the tertiary, or even the commencement of the present epoch.

The second of these later systems of volcanos, namely, those in the vicinity of the hills named the Humrichs, began later than the revived eruptions of the lake of Laach, and were even conti-

nued later, so as to extend to a period so very recent, as to render it somewhat doubtful if they were not actually prolonged to historic times.

After this explanation it will be evident, that we are entering upon a new interval;—an interval, which, if still not free from volcanic convulsions, will at least show that the volcanic activity had undergone a considerable abatement.

At the commencement of this period, the banks of the basin of Neuwied began to be covered with forests, the progenitors of the present stock, while the races of animals then subsisting, some of which are now extinct, ranged in numbers among the woods or on the borders of the lake, their resort to this site being only interrupted by occasional or much abated volcanic convulsions.

I am also inclined to suspect, for reasons which will be stated hereafter, that about this period man became a tenant of the soil of western Europe, though in his most savage state of habits.

Lastly, the disintegration of the primary rocks, as well as the tertiary strata of the basin of Neuwied, at length began to exhibit a progress of waste differing little from what is exhibited at the present day, having evidently undergone a diminution of its ancient rapidity. This more slow process can scarcely fail to be attributed to a very different state of the atmosphere which must have then prevailed, by which the surface of the earth was rendered compatible with the existence of the present vegetable and animal races.

## CHAPTER XXII.

### THE LATER ERUPTIONS OF THE CRATER OF LAACH.

No part of the geology of the basin of Neuwied is so difficult to be understood as that which relates to the lake of Laach. Indeed, it would be in vain to attempt an explanation of the various substances ejected from this crater during the last convulsion which it experienced, without assuming certain historical incidents connected with its earliest formation, to which we are led from analogy, or from considering what actually took place in other craters, the depths of which are better known to us, such as those of Rieden and Fusel.

In the fifth chapter of this work, (page 21 to 27,) I entered at length into this hypothetical history, reserving, as I mentioned, its elucidation for a more advanced period of this investigation. I shall therefore now remark, that after having described

in minute detail the volcanic operations of the crater of Rieden, there will, I think, be no difficulty in obtaining an assent to the great probability, that during the commencement of the tertiary epoch the self-same process might have been going on in the crater of Laach, the depths of which have been necessarily concealed from us by the deep deposit of plastic clay and sand which it received as a crater lake, owing to its communication and the intermingling of its waters with the great lake of Neuwied.

One supposition which I entertained was, that, either coincident with the crater of Laach assuming the state of a crater lake, or subsequently to this event, felspathose rocks of volcanic origin, in issuing from a deep focus, had ascended, in the form of veins or dikes, through the vent of the crater, displacing most of the debris with which the orifice was choked up, as well as entangling many shattered fragments within its viscid substance.

Another supposition was, that an eruption of pulverulent and pumiceous particles of trachyte, so frequently the concomitant of trachytic volcanos, had ascended through the vent of the crater, and having been intercepted by the waters of the crater lake, had formed a deposit of tufaceous substance with which the trachyte was surmounted.

This was the hypothetical history which I then assumed, leaving its confirmation for a future consideration. It of course involved the notion, that this early eruption of trachyte did not rise to any considerable height, but that it had remained concealed below the level of the waters of the crater lake.

The remaining portion of the history of the Laacher-see is evident enough.

The crater of Laach, in consequence of its juxtaposition to the great tertiary lake of Neuwied, became filled with a deposit of plastic clay and sand, the remains of which are still evident. (See page 77, &c.) This deposit is of course inferred to have been superimposed upon the dikes or cones of trachyte which had been protruded from the depths of the crater.

Since this period, down to nearly the close of the tertiary epoch, the lake of Laach appears to have suffered no violent change. The volcanic phenomena which then began to appear may be successively considered after the following manner:

1*st*, The eruptions occurring around the margin of the Laacher-see;

2*dly*, The still later eruptions which had their origin from the depths of the crater itself; with the historical information which the various ejected products communicate of the earlier state of the basin of Laach;—and,

3*dly*, The prolongation of the later eruptions to the close of the tertiary, or even to the commencement of the present epoch.

## SECTION I.—THE ERUPTIONS OCCURRING AROUND THE MARGIN OF THE LAACHER-SEE.

The present section is devoted to a consideration of the eruptions which have had their origin, not in the crater itself of the Laacher-see, but in the rocks of clay-slate which form its margin.

In considering the crater of Laach as a vast circular aperture from which minor fissures of a longitudinal form have radiated, it is not irrational to suppose that such fissures might have proved the predisposing cause of the basaltic eruptions which have occurred round a central aperture, such as we are contemplating.

But this view has been before supported on the following grounds:

It has been explained, that the crater of Laach is perhaps the oldest volcanic eruption in the Lower Rheinland, bearing date from the very commencement of the tertiary epoch, and immediately preceding the plastic clay deposit, with which, owing to the junction of its waters with those of the lacustrine expanse of Neuwied, it was filled.

In treating of the lateral fissures connected with the central aperture of the Laacher-see, the remark of Von Buch was noticed, that if we suppose a succession of solid and unelastic strata to be suddenly acted upon from below by the expansive force of elastic fluids, it is evident that not merely would a central aperture be formed, but that this strain would occasion a number of lateral fissures. In noticing such presumed fissures I added, that some of them which have radiated, as it were, from the central aperture of Laach, were to be detected by another species of evidence;—namely, that, in a subsequent period, they had favoured the eruption through them of basaltic lava, or, in other words, that these fissures had afforded the predisposing condition by which columns of volcanic matter had in their ascent been enabled to reach the surface of the earth;—and that fissures or rents of this description might be traced west of the Laacher-see as far as the hill named the Gansehals, to the north of it as far as the trass valley of the Brühl, to the south of it as far as the millstone quarries of Niedermennig, and to the east of it as far as Eich.

This view is certainly much countenanced by the direction of many eruptions of lava which appear to have radiated in every direction round the crater of Laach, and which, we are entitled to conjecture, ascended through very ancient rents.

All the eruptions which appear to have observed this distribution we have at length considered, with the exception of those which have had their origin in the fissures which are to be found nearest to the crater of Laach, or around its marginal cliffs.

Regarding these as well as other later eruptions round the crater of Laach, it may be remarked, that they differ little in their

mineralogical character from many which have been described. The black or grey volcanic sand, and the cinders, give evidence that in all or most of them gaseous matter was extricated. But the lava flows which have issued from the apertures thus formed are the most characteristic of these volcanos, though none of them are considerable. The basaltic lava (for this is its general character,) shows here a remarkable hardness, and it contains fine and perfect crystals of augite. In general, it exhibits fewer marks of fire than in other eruptions recited, being less porous or scoriated. There is also contained in it, though much less plentifully, crystals of a reddish coloured felspar, occasionally reduced to the state of a porcelain. Where the rock appears much scorified, (and we certainly find some loose blocks of lava in this condition,) besides augite, it contains, though less plentifully, mica, which has been described as of a tobacco-brown colour.

After these very general remarks, I shall proceed to describe in their order the volcanos which may be situated on the northerly, westerly, southerly, or easterly limits of the crater of Laach.

### 1st, *The Eruption on the northerly margin of the crater of Laach.*

One slight eruption may be described as existing on the northerly margin of the lake, which is indicated by the many blocks of a dark-coloured basalt, unscorified, or very little so, containing crystals of augite, which we find half-concealed by underwood or the deep volcanic sand of the lake. These blocks will be found to lie to the east of the very white and prominent remains of the plastic clay deposit, which appear in a sort of patch upon the north side of the lake.

### 2dly, *The Volcanos to the west of the Laacher-see.*

The eruptions to the west of the Laacher-see are those which are situated on the north-westerly bounding cliffs of the lake of Laach, and an inconsiderable one which is situated to the south-west of this great crater.

(*a.*) THE ERUPTIONS WHICH HAVE TAKEN PLACE FROM THE NORTH-WESTERLY BOUNDING CLIFFS OF THE LAKE OF LAACH.—A small slagged-top hill lies to the north-west of the lake of Laach, where may be found a few basalt blocks.

But a far larger and more important one is the VEITSKOPF, to which I shall now confine my attention.

It has been shewn in the sixth chapter, (page 49,) that one of the greatest drains for the overflow of the tufaceous mud or moya from the crater of Rieden was an ancient lake, in some places of considerable depth, which extended from the northerly boundary

of the high hill of the Gansehals in a direction north by east as far as the volcanic hill named the Lummerfeld. This tertiary lake, the deep bed of which had probably been induced by volcanic causes, I have named the lake of Gleis. It was drained by a stream situated to the north, by which any overflow was carried into the Bruhl.—(*See the Geographical Sketch, p.* 130.)

Now, by consulting the general map it will be evident, that the Laacher-see was separated from this ancient lake on the north-east by a very narrow yet high ridge of clay-slate. This, then, was the site, now named THE VEITSKOPF, from which an eruption took place of volcanic matter.

The cinders and slag to be traced at the top of the hill show the nature of the eruption. It would appear that from this vent two slight flows have issued; that, while the one has descended towards the lake of Laach, the other on the opposite side has fallen into the lake of Gleis, its course being traceable in a direction towards the village of that name. The lava is of the kind which I have already described, as existing on the margin of the Laacher-see. It is only in a small degree porous or scoriaceous, and it contains crystals of augite.

M. Steininger and other writers think that a large crater is developed in the hill of the Veitskopf. There is certainly much of the appearance of one upon the westerly side of the hill; but it rather appears to me to have been caused by the action of rains upon the tufa which lines the side of the hill, derived, as I have shown, from the overflowings of the tufaceous mud of Rieden into the lake of Gleis.

There is also an appearance of an addition to the height of the Veitskopf having been induced by an eruption of the tufa from the Laacher-see. But, as I conceive that this has been the result of a later explosion from the crater of Laach, an investigation of this appearance will be remitted to a future section. At the same time it is by no means unlikely, though it is incapable of being proved, that, during the basaltic eruption of the Laacher-see, at present described, some little of the ancient contents of the lake, consisting of yellow tufa, mixed with sand or plastic-clay, as well as fragments of trachyte, forced from the extreme depths of the lake, might have been thrown up, and might have been mixed with the tufa of the lake of Gleis.—For the reasons, however, assigned, a description of this ejection will be reserved for the conclusion of the chapter. (See p. 164.)

(*b.*) AN INCONSIDERABLE ERUPTION ON THE SOUTH-WESTERLY MARGIN OF THE LAACHER-SEE.—On the south-westerly margin of the Laacher-see, a little to the north of the Abbey of Laach, is another eruption of basaltic lava, resembling in character that of the Veitskopf. And, according to M. Steininger,

a slag-topped hill lies to the north-west, near the crater. Here may be found a few basalt blocks.

### *3dly, The Eruptions of Scorified Basalt on the southerly margin of the Crater of Laach.*

On the southerly margin of the Laacher-see, there are three or four minor eruptions of scoriaceous basalt to be observed. Black volcanic sand, cinders, and fragments of basalt slag, particularly the latter, constitute their general character. They will be found a little to the south-east of the abbey of Laach, and, in another site, due south of the crater.

### *4thly, The Eruption on the easterly margin of the Crater of Laach.*

An eruption has occurred on a high hill, forming the exact easterly boundary of the crater of Laach. It is composed of a blue basalt, of rather a dull earthy-looking character, yet compact. There are no signs of any crystals in it. The ingredient of felspar appears to have entered into the composition of the basalt in rather more than its usual proportion.

The point of eruption to which this basalt may be traced, is indicated by a rock which appears to project or stand out like a wall. There has probably been a slight flow down the steep declivity towards the lake, which is to be inferred from the numerous blocks which are there found.

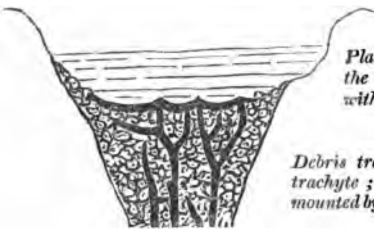
These remarks conclude my observations on the eruptions of basalt slag, which appear to have broken out, not from the crater itself of Laach, which was unaffected by them, but from the clay-slate rocks which form the margin of the lake.

My next object, therefore, will be to explain in

## SECTION II.—THE STILL LATER ERUPTIONS WHICH HAD THEIR ORIGIN FROM THE CRATER ITSELF OF LAACH, WITH THE HISTORICAL INFORMATION WHICH THE VARIOUS EJECTED PRODUCTS COMMUNICATE OF ITS EARLIER STATE.

In the view which I have taken of the earliest state of the crater of Laach the sum of my speculations was, that if by drainage we could explore the great depths of the lake itself, of which our most evident information is derived from the remains of strata of plastic clay and sand which line its margin, it is by no means improbable that an eruption of trachytic rocks, coated over by a tufaceous deposit, perhaps a slight one, would be manifest, resembling that which has occupied the depths of the basins of Rieden and Fusel.

But to render more perspicuous the views which I have inculcated, I shall revert to an ideal section, given in page 27 of this memoir, in which I endeavoured to represent the supposed internal distribution of the contents of the lake, which consisted, 1*st*, of the debris which choked up the orifice of the crater, as it is traversed by dikes of trachyte; 2*dly*, of the tufa by which the debris was supposed to have been coated over; and, 3*dly*, of the thick deposit of plastic clay and sand, (intermingled in its upper beds with ejected moya from Rieden,) by which the whole was surmounted.




After this preliminary view, I shall consider, in the course of this section, the proofs which are afforded of this early state of the crater of Laach, as it is revealed to us by a species of evidence which incorporates itself with its latest geological history.

Near the close of the tertiary epoch, the fires of the volcanic focus, subsisting beneath the depths of the crater-lake of Laach, appear to have been rekindled. This effect was accompanied by the extrication of elastic fluids, which forced for themselves a renewed passage through the vent, which had long since been choked up.

In the nature of the various substances ejected, which, as I shall shew in a future part of this chapter, may be regarded as the result of a series of minor and prolonged explosions, may be read the earlier history of the basin of Laach. The ejected substances may be summed up as follows:

1*st*, Fragments of primary rocks, either forced from the walls of the crater during the disengagement of elastic fluids, or from the older debris, which, at the commencement of the tertiary epoch, had choked up the vent.

2*dly*, Fragments of the volcanic rocks, which, in the same early tertiary period, are supposed to have ascended through the debris in the form of dikes, but which became submerged under the waters of the crater-lake.

3*dly*, Fragments of the ancient tufa, which, soon after the ascent of dikes of trachyte, is supposed to have formed a bed over them, or a sort of tufaceous coating.

*4thly*, Ejected matter from the lower tertiary beds, which, subsequently to the protrusion of debris of trachyte, had filled the crater of Laach as a lacustrine deposit.

*5thly*, Matter from the upper beds of the south of the crater of Laach, consisting of tufaceous mud, or moya, which, having been ejected from the basin of Rieden, had become commingled with the deposit then going on of sand and plastic clay.

Such is the list of ejected products which is open to our examination on the margin of the crater of Laach, as the result of the latest explosions of this volcano. These dispersed substances we shall now examine in the order which I have explained.

1*st, Fragments of the Primary Rocks either forced from the ancient walls of the Crater during the disengagement of elastic fluids, or from the older debris, which, at the commencement of the Tertiary Epoch, had choked up the Vent.*

The ejected fragments indicative of the succession of primary rocks through which at the commencement of the tertiary epoch elastic gases had forced for themselves a vent, or of the fragments which had originally choked up the vent of the crater,—are various. They do not only consist of the common primary rocks of clay-slate, or grauwacke schist, common to the district, but of such deeper-seated rocks, as mica-slate, gneiss, and granite. In fact, we are informed by the fragments thus thrown up, that the deepest seated rocks through which a crateral aperture had been forced consisted of granite; and that to this fundamental rock had succeeded gneiss, mica-slate, and clay-slate.

These I shall describe in their order:

(*a.*) Granite.—Granitic fragments, generally more or less altered by heat, are abundantly found. One specimen among them, the least affected by fire, much resembled a specimen which I described as ejected by a volcano in the vicinity of the High Kelberg, (see page 69,) though perhaps it contained more hornblende disseminated through it. Other specimens shewed a diversity in the superior crystalline state of the particles of hornblende which they contained; but whether this difference did not in part result from the subsequent action of heat given out by the volcanic focus, it may be a future question of interest to solve. Some of the specimens I collected contained very imperfectly crystallized portions of felspar of a blue lilac colour, and of an opalescent lustre, one of which was more than two inches in length, and about half an one in breadth. This modification was probably the effect of heat. In another specimen crystals of magnetic iron occurred.

(*b.*) Gneiss.—Among ejected fragments of the lake of Laach I obtained a specimen exhibiting the junction of granite and gneiss, whence it may be inferred, that in an order of superposition gneiss

succeeded to granite. But besides this fragment, I collected various others consisting solely of gneiss, in which more varieties than one of this rock might be detected.

The first of these varieties was a dark greyish-coloured gneiss, chiefly composed of a pale-coloured felspar and minute scales of mica, through which I found magnetic and specular iron ore to be diffused, as well as sphene; the latter much more sparingly. A second variety of gneiss, admitting two or three lighter shades of colour, contained still more felspar interlaminated with minute scales of mica;—while a third variety was of a brownish-red tint variegated with shades of a cream colour. It contained crystals approaching to a vitreous lustre.

All these fragments appeared to be more or less affected by heat. Some even approached to the state of a glassy slag, or even to pumice. In one specimen the interlaminated felspar resembled obsidian.

(*c.*) Mica-slate.—Fragments of mica-slate, generally affected by fire, are more sparingly found. It is sufficient to remark of them, that the mica appears of a very dark liver brown colour.

(*d.*) Clay-slate.—Fragments of clay-slate are also, as we might expect, abundantly found.

I might add, that I found another fragment which I am inclined to consider as having proceeded from some subordinate rock belonging to the primitive class. It appeared to consist of an immense congeries of very black minute crystals of basaltic hornblende, though it was evident, from some decomposed specimens, that felspar was much diffused through the mass. I also detected in this specimen minute crystals of magnetic iron.

Such are the ejected fragments indicative of the succession of primary rocks through which elastic gases had forced for themselves a vent.

*2dly, The Fragments of Trachytic Rocks which may be supposed to have ascended through the debris of the Crater in the form of Dikes, and to have become submerged under the waters of the Crater-lake.*

The nature of the trachytic rocks which first occupied the depths of the crater of Laach in the form of dikes are here conceived to have been made known to us during the progress of much later explosions, by which abundant fragments of them, most of them altered by recent fires, were ejected.

Many of these volcanic fragments much resemble some varieties of granite, and thus give countenance to Dr Daubeny's notion, that trachyte is merely a granite altered by volcanic fires. But into the merits of this hypothesis, I cannot allow myself space to enter.

One of these rocks has certainly a granitic structure, being composed of semicrystalline grains, chiefly of felspar. These grains differ in their magnitude in different crystals. The largest of them scarcely exceed those of a fine-grained granite, while the smaller are almost imperceptible without the aid of a microscope. The felspar is of a greyish-white, milk-white, and even of a greenish-white colour; but its particles differ from those of granite, by shewing almost altogether a vitreous lustre, or, in other words, the rock, instead of common, contains glassy felspar. The other ingredient of this rock is basaltic hornblende, which is disseminated through it in the form of minute crystals. Small drusy cavities abound, which are lined with mammillated particles resembling the substance of prehnite.

A second fragment of rock of a volcanic origin is of the same granitic character, but is distinguished by the presence of additional ingredients. It is composed of semicrystalline grains of glassy felspar, which show all the intermediate changes from a transparent white to a yellowish-brown colour. Intimately and thickly blended with these are small black crystals of basaltic hornblende. But the substance which gives to this variety of the rock its peculiar character is the interspersion of particles of Hauyne of a splendid Berlin-blue or sapphire-blue colour. In this rock are also found specks of magnetic iron and titanite. Mica is said to be an ingredient; but in the specimens which came under my own notice I could not detect this mineral. Certain very minute yellow particles which it contains have, I believe, been described by mineralogists under the name of chrysolite, which, however, is nothing more than another name for olivine. Noeggerath adds apatite to the list of ingredients which these fragments contain.

This rock is again susceptible of modifications. In some specimens its granitic character becomes gradually lost, and it acquires a felspathose base of rather an earthy appearance, and of a bluish-black colour, varied, however, by the interspersion throughout it of extremely minute crystals of hornblende, which are densely fixed in it as in a sort of paste. It is again very beautifully variegated by numerous crystals of Hauyne, which in some spots are so thickly diffused as to give it a prevailing sapphire-blue colour. And, to add to the splendour of this rock, fine transparent crystals of glassy felspar, of a splendid pearly lustre, and often about the third of an inch in length, appear scattered throughout it. This is one of the most elegant rocks which can possibly meet the eye of the geologist.

Such are the ejected fragments which approach in character to those of granite,—so nearly, indeed, as to give some little weight to the hypothesis, that they are merely pyrogenous modifications

of this rock. They appear, if we may judge from the numerous weathered portions which are strewed about the lake, to be much prone to decomposition; the substance of glassy felspar and Hauyne being generally the least decomposable, and remaining after the other ingredients of the rock have assumed a pulverulent form.

Many of these fragments have been much affected by volcanic fires, so as even to be reduced to a state approaching to that of pumice.

But I have yet to describe the most prevalent fragments of trachyte which have been ejected.

Certain of these have a base of felspar of a bright bluish-grey colour. In this base are disseminated numerous crystals of glassy felspar, very white and translucent, the prevailing size of which is from the tenth to the half of an inch. Among these fragments small crystals of hornblende are abundantly diffused. In short, the rock may be briefly described as having a bluish-grey felspathose base, wherein crystals of glassy felspar and hornblende are disseminated; added to which other occasional ingredients appear, such as crystals of augite, scales of black mica, Hauyne, or sodalite.

Of the substance thus described, I have suspected that the volcanic rocks which were very early protruded from below the waters of the crater-lake were chiefly composed. But, by the greater or less operation of much later volcanic fires, a remarkable change in the external character of these materials seems to have ensued.

By a slighter operation of heat the base of the rock appears to have undergone no further alteration than is shown in the minute pores which it exhibits.

From a greater application of heat, its base has in numerous ejected fragments passed from the colour of bluish-grey, and from a lustre which is pearly, to one that is of a dirty fuliginous black hue, than which nothing can be conceived of more dull. Its porosity has likewise increased with the change, as well as its irregularity of structure, which are conjointly indicated by a peculiar roughness to the touch. At the same time, the hornblende has been occasionally converted into a sort of pitchstone.

And, *thirdly*, from a still more intense application of heat, the rock has, in many instances, become specifically much lighter and more porous, so as even to approach the character of a black cinder, or even of a grey pumice. Its inclosed crystals of glassy felspar have also partially disappeared, or have assumed the state of a pumice, leaving behind them irregular pores. Hauyne, however, seems in many cases to have survived the effects of this increased temperature. Other varieties of contained minerals are not so fortunate, having been lost in the new homogeneous complexion which the mass has occasionally assumed.

There is again another form which the ejected trachytic fragments have put on, which is that of ellipsoid balls, variously called *amandes volcaniques*, *larmes volcaniques*, or *bombes*.

*Lastly*, the felspathose substance described appears as a grey or dark-coloured sand, which seems to have been projected in extraordinary quantities from the depths of the crater of Laach. We find among its particles comminuted grains, generally in an attrited state, of glassy felspar, basaltic hornblende, or titaniferous magnetic iron ore, varied with minute portions of Hauyne, and many other still rarer minerals of the rocks which have been described. Much of this sand, at the same time, must have resulted from the comminution to which the larger volcanic fragments of the lake have been subjected by the operations of mountain torrents, and must have been also mixed with the black sand given out during the course of the previous basaltic eruptions which took place from the heights that bound the crater of Laach.

These are all the kinds of volcanic substances which I observed strewed in fragments in the vicinity of the Laacher-see, with the exception of one solitary broken mass which fell under my observation of rather a different character. Its base was a felspathose substance, of a brownish purple-red colour, variegated with paler shades, a little porous, or containing small cavities the sides of which were incrusted with a blackish powdery substance resulting probably from decomposed or burnt crystals of hornblende. This rock contained crystals of felspar that no longer retained their vitreous state, but seemed to have been reduced to the state of a pumice.

But there is perhaps no character by which these various products are more distinguished than in the variety of minerals which they contain, at a leading few only of which I have yet glanced. Accordingly, the banks of the Laacher-see are annually visited by mineralogical collectors, from the result of whose labours I shall endeavour to render a list of such as have been discovered, either contained in the various volcanic rocks which I have described, or mixed with the dark volcanic sand of the lake.

(*a*.) Glassy Felspar.—The beautiful small crystals of glassy felspar, which rival in their clearness the most limpid water, have been already alluded to. They give a principal character, from their extraordinary abundant diffusion, to the various felspathose products of the Laacher-see.

(*b*.) *Hornblende*.—Crystals of basaltic hornblende are in some ejected volcanic fragments plentifully disseminated.

(*c*.) *Augite*, as we might expect in felspathose rocks, is comparatively a sparing product.

(*d.*) *Mica.*—Scales of a dark-coloured mica are found diffused in many fragments; but I have been in doubt whether or not to consider them as entangled fragments, torn from the primary rocks of which the walls of the crateral vent were composed.

(*e.*) *Titaniferous magnetic iron ore.*—Small octahedral crystals of titaniferous magnetic iron ore, of an opaque and iron-black colour, must be considered as rather abundantly diffused through the volcanic products of Laach, which, from their existing among the disintegrated materials of the crater in a state of preservation, having survived the decomposition of other ingredients, give a corresponding character to the volcanic sand of the lake.

(*f.*) *Titanite.*—Grains of titanite, named by writers on the volcanos of the Rheinland, yellow Menakerz, or semeline, are found under the same circumstances as titaniferous magnetic iron ore.

(*g.*) *Hauyne.*—This mineral, which is not only found in the ejected volcanic fragments of the crater, but likewise diffused through the sand of the lake, does not occur in particles so large as we observe them to be in the lava of Mennig. (See page 124.) Its particular localities have been referred by authors to the north-east and the east of the Laacher-see. The Hauyne of Laach is of a fine blue colour, but regular crystals of it are seldom or ever met with. Its specific gravity varies from 2.350 to 2.500. The Hauyne of Laach has been analysed by Bergemann, the result of which is as follows:

| | |
|---|---|
| Silex, - | 37. 0 |
| Alumina, - | 27.50 |
| Lime, - | 8.14 |
| Soda, - | 12.24 |
| Sulphuric acid, | 11.56 |
| Oxydulated iron, | 1.15 |
| Oxide of manganese, | 0.50 |
| Water, - | 1.50 |
| | 99.59 |

(*h.*) *Meionite.*—This is another product of Laach allied to Hauyne, but differing from it, according to M. Brongniart's nomenclature, as follows:—while he expresses the chemical composition of Hauyne under the terms "potasse et alumine *silicatées*," he describes that of meionite as "potasse et alumine *sursilicatées*." Pyramidal crystals of this mineral are said to have been found at Laach in the form of grains, but M. Von Leonhard, in his geological system, places a query to this supposed locality.

(*i.*) *Nosin.*—This mineral substance appears in the form of crystalline grains of a colour varying from greyish-black to ash-grey; from a waxy to a vitreous lustre; from a conchoidal to a

smooth fracture; and from an undiaphanous to a diaphanous state. It is chiefly found near the Kloster Laach; in the sand pits near the Veitskopf on the way to Gleis; and in a wood to the north of the Laacher-see. It has been remarked by one author, that it is distinguished from the Hauyne of Laach by its greyish-black and brown colour; by its approach to opacity; or by its being only transparent on its edges. It is likewise stated that it has been confounded by writers with hornblende, but more particularly with magnetic ironstone. The analysis of the nosin of Laach has been given by Bergemann.

| | |
|---|---|
| Silex, - | 38.50 |
| Alumina, - | 29.25 |
| Lime, - | 1.14 |
| Soda, - | 16.56 |
| Sulphuric acid, | 8.16 |
| Oxide of manganese, | 1. |
| Oxydulated iron. | 1.50 |
| Water, - | 3. |
| Loss, - | .89 |
| Total, | 100.00 |

(*k.*) *Sodalite.*—Crystals of sodalite, in the form of dodecahedrons, of a white, light-grey, or light-green colour, and approaching to semi-transparency, are discovered among the volcanic fragments of the lake. I am not aware that this mineral, as it is found at Laach, has, like Hauyne or Nosin, met with any analysis. In other distant localities it has been found to contain 35 to 44 parts per cent. of silex, 23 to 32 parts of alumina, and about 27 parts of soda, whence its name, mixed with a little potash.

(*l.*) *Nepheline.*—Crystals of nepheline, which M. Brongniart designates as an *alumine silicatée*, form another mineral product of Laach. Nepheline has been particularly described in my account of the Mennig lava, of which it is an ingredient. *(See page 124.)*

(*m.*) *Apatite.*—Crystals of apatite, (chaux phosphatée,) consisting of six-sided prisms, perfectly transparent and colourless, are found in small druses. The same have been also detected in a volcanic bomb consisting of a granular mixture of felspar and hornblende.

(*n.*) *Cordierite.*—This is the iolite, pelium, and prismatic quartz of various authors. Its chemical nature is expressed by Brongniart under the title of *magnesie aluminatée et fer silicatés.* Crystals of it are derivations of a regular hexahedral prism, but, at Laach, the crystalline form of cordierite is lost in its confused intermixture with other substances, as with glassy felspar and mica. It is here

distinguished by its lavender-blue colour. M. Von Leonhard generally describes the mineral as being, in the direction of its axis of crystallization, of an indigo-blue colour, but, at right angles to the axis, of a brownish-yellow tint. It is also doubly refractive.

*(o.) Melilite*, according to some writers, is a product of Laach, though M. Von Leonhard is silent regarding this locality. According to this mineralogist, the prismatic form of the crystal is a rectangular octahedron. In an analysis of the melilite of Italy, it was found to contain 38 parts per cent. of silica, 19 of lime, 19 of magnesia, and 12 of the oxide of iron, along with some little alumina, titanium, and manganese. It is described as opaque, with a yellow colour inclining to red or green.

*(p.) Zircon.*—Imperfect prismatic crystals of this mineral, of a greyish white colour, and almost transparent, are found, though very sparingly, in small drusy cavities, through which a rose red tint is diffused. The same druses are lined with crystals of felspar, mica, and augite.

*(q.) Spinelle.*—According to M. De Wyck, (p. 86 of his treatise,) spinelle is found at Laach;—though M. Von Leonhard does not give this locality. Spinelle is generally described by Brongniart as *magnesie silicatée*, with crystals derived from a regular octahedron.

*(r.) Noble Garnets* are stated by MM. Noeggerath and De Wyck to have been found. It has also been remarked that they were associated with cordierite.

*(s.) Melanite*, or the dodecahedral garnet, is likewise stated as a product of Laach, though M. Von Leonhard does not assign this locality to it, or even to the noble garnet.

*(t.) Olivine* has already been described, (p. 154.)

With this list of minerals contained in the fragments of the volcanic rocks found at the lake of Laach, which, in an early tertiary period, are supposed to have ascended through its debris in the form of dikes, having been at the same time submerged under the waters of the crater-lake,—I shall now conclude.

[*For various particulars regarding the minerals of the lake of Laach, consultations may be made to the following works: Handbuch der Oryktognosie von Carl Cæsar von Leonhard, &c. Heidelberg*, 1826;—*Noeggerath's Rheinland Westphalen, &c.* Vol. i. p. 366, &c. Vol. ii. p. 302 to 348, and Vol. iii. p. 286, &c.;—also *Uebersicht der Rheinischen und Eifeler eloschenen Vulcane, &c. von H. J. Freiberrn van der Wyck*, p. 77 to 87;—*Lastly, reference may be made generally to the works of M. Steininger, in which various incidental notices occur of the Oryktognosy of Laach.*]

*3dly, The fragments of the ancient tufa, which, soon after the ascent of the dikes of Trachyte, is supposed to have formed a bed over them, or a sort of tufaceous coating.*

Among the ejections of the crater of Laach I must enumerate fragments of a hard tufa, much resembling the ovenstone of Bell, which there is little doubt has had a similar origin. It must have coated over the eruptions of trachyte which had been protruded beneath the depths of the lake, prior to the deposit of sand and plastic clay which the crater lake of Laach had received, when its waters were mingled with those of the basin of Neuwied.

In one specimen I found the tufa acted upon by heat, and having a sort of enamelled coating on the outside. This was probably occasioned by later fires.

*4thly, Ejected Debris from the lower Tertiary beds, which, subsequently to the protrusion of Dikes of Trachyte, had filled the crater of Laach as a tertiary deposit.*

The deposit which filled the crater lake of Laach, when its waters were commingled with those of the basin of Neuwied, consisted, as I have before explained, of sand and plastic clay. Upon the later rekindling of the volcanic fires, by which dikes of trachyte, supposed to have been protruded at a very early period beneath the depths of the lake, were broken up, the sand and plastic clay which filled the lake would likewise be broken up, and dispersed in every possible degree of confusion,—mixed with volcanic fragments and with volcanic sand.

That such an appearance presents itself in certain parts of the crater of Laach is sufficiently evident. To the north and northeast sides of the lake, at least in some spots, the forcible ejections of a later period scarcely seem to have extended; and, as a consequence, we find that beds of sand and plastic clay appear in small patches perfectly undisturbed along the declivity of the high slate rocks which form the bounding sides of the crater.

It is rather remarkable, that among the ejected debris of Laach I found a fragment of tertiary limestone evidently affected by fire, which was of marine origin, resembling that of Mayence, and containing pectens and other bivalves. On finding it, I instantly conceived that its presence, as an ejected fragment of the Laacher-see, indicated, that, prior to the fresh water beds which were deposited in it of sand and plastic clay, the lake of Laach had subsisted as a marine crater; and, consequently, that its first existence as a volcano might be referred to the dawn of the tertiary epoch, before the rocks which form the basin of Neuwied had appeared above the surface of ancient European seas.

Entertaining these speculations, I sought to find other similar

fragments resembling the Mayence limestone, but was perfectly unsuccessful. In the absence, therefore, of a confirmation to my conjecture, I am compelled to consider this solitary fragment as an erratic one;—having been washed to this site during one of the convulsions which the Lower Rheinland experienced in the course of the tertiary epoch, and which became subsequently acted upon by volcanic fires. Additional proofs that this is the most plausible explanation of the mysterious fragment will be afforded in a subsequent chapter.

Another ejected fragment, the history of which I was unable to explain, appeared in the form of a cavernous quartz rock very slightly affected by heat, and much resembling the buhrstone of the Paris formation. This might also have been an erratic fragment, or perhaps even a quartzose fragment detached from transition rocks, and peculiarly modified by volcanic heat.

*5thly, Debris from the upper beds of the deposit of Laach, consisting of tufaceous mud, or moya, which, having been ejected from the Basin of Rieden, became commingled with the deposit then going on, of sand and plastic clay.*

In entering upon an examination of these ejections it is necessary to remark, that the lacustrine deposit which has been thrown up by later explosions is not always unmixed with extraneous matter. It must be recollected, that the crater of Laach subsisted as a sort of creek, into which the waters of the basin of Neuwied flowed, and that these waters had subsequently received much of the overflowed moya from the crater of Rieden. Hence we may infer that this tufaceous substance became intermingled with the upper beds of the common lacustrine deposit. This intermixture, which is not exhibited on the north or north-east of Laach, becomes decided when we recede from the sides of the crater, particularly to the south of it, where the crater-lake communicated with the lacustrine expanse of Neuwied.

On the south, south-west, and west, of the Lake of Laach, numerous small elevations, of a very tufaceous aspect, may be detected, indicative of the matter of which they are composed having been derived from the moya of the cauldron of Rieden, which, in overflowing the walls of its crater, had been washed by currents to the depths originally subsisting on the south of the crater of Laach, where it would become mixed with the common deposit of plastic clay and sand.—(See page 43.)

The deposit having thus been formed, we can readily explain in what manner later eruptions of the crater of Laach, in throwing up indiscriminately mixed volumes of sand, plastic clay, and tufa, have subsequently formed an heterogeneous commixture, in which volcanic fragments, as well as the fragments rent from fissured walls, are equally confounded.

When the sand or plastic clay is pure, it is often of a wax-yellow appearance, but when it is mixed with tufaceous matter, it assumes a yellowish-brown colour, of an earthy and dirty appearance.

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With this description, I shall conclude my account of the various products thrown up by the crater of Laach during a later series of prolonged explosions, and of the historical information which they communicate of its earlier state.

The investigation has included such fragments of the primary rocks as have been forced from the walls of the crater during the disengagment of elastic fluids, or from the older debris which had choked up the vent;—it has comprehended the ejected fragments of the volcanic rocks which are supposed to have ascended through the debris in the form of dikes, and to have been at the same time submerged under the waters of the crater-lake;—it has comprehended such ejected fragments of tufa as might have formed a bed over the dikes of trachyte which had been protruded in the form of a tufaceous coating;—it has included the ejected matter of sand and plastic clay, which, subsequently to the protrusion of dikes of trachyte, had filled the crater of Laach as a lacustrine deposit;—while, lastly, it has extended to such ejected matter forced from the upper beds of the south of the crater of Laach, as have consisted of tufaceous mud, or moya, ejected from the basin of Rieden, and commingled with the deposit then going on of sand and plastic clay.

This investigation having been concluded, I shall next proceed to point out

## Section III.—The prolonged duration of the later eruptions of the crater of Laach, together with the more general appearances which they present around its margin.

It is now necessary to observe, that the renewed convulsions of the crater of Laach were rather characterized by a succession of minor eruptions taking place from small apertures developed in different parts of the crater-lake, than from one grand explosion issuing from the whole compass of the great aperture of the Laacher-see. Consequently, the phenomena would bear some resemblance to the partial jets composed of earthy matter, mud, and fragments of rocks of various kinds, which characterize some few volcanos that subsist in modern times.

At the same time, the force with which the greatest part of the contents of the crater of Laach was broken up appears to have been so great, as to carry them high up in the atmosphere, where

they must have become subject to currents of air that have dispersed them over a few miles of surface encircling the Laacher-see.

The various fragments of primary or of older volcanic rocks forced from the depths of the vent, accompanied with the clouds of lacustrine sand and clay mixed up with tufaceous particles which appear to have been projected during the breaking up of the contents of the basin of Laach, have, by their accumulation around the margin of the crater-lake, considerably lessened in some places the original extent of its circumference.

After these very general remarks, I propose to describe the various evidences afforded of these later convulsions, as they are observable in certain parts of the circumference of the crater of Laach.

The chief accumulation of debris thrown up during the later explosions of the crater of Laach is to be seen on the south-east and north sides, where the crater-lake has communicated with the large lacustrine expanse of Neuwied. This was a great seat of the later volcanic energy, where, owing to the depth and flatness of the shore, the ejected sand and fragments appear in the form of small sand hills. This is well shewn in the sketch of the southerly shores of Laach, which is to be seen in Plate II. page 23.

On the west and north-west sides of the lake, wherever the bounding rocks of clay-slate become less steep and precipitous, they are covered over with ejected debris.

On the north and north-east margin, which is flanked by very steep rocks, either no eruption has taken place, or it has been so small that the accumulation of ejected materials has not been sufficiently great to advance itself above the level of the waters. There is to be detected on the north side of the lake patches of the general fresh water deposit of Neuwied, which, amidst all the later convulsions of the crater, have remained undisturbed.

After this explanation, I shall notice more particularly the effect of the different and successive volcanic eruptions which have taken place, as they appear at the various margins of the crater-lake.

(*a.*) The south easterly margin of the crater of Laach.—On the south-east of the crater of Laach a considerable effect has taken place from a series of minor eruptions. We here find much sand thrown up little intermingled with tufaceous matter, throughout which volcanic fragments or cinders are dispersed in an abundance that is remarkable. Occasionally, there is a tendency to an interstratification of lacustrine and volcanic matter. Ellipsoid portions of slag, commonly named bombs, *amandes volcaniques*, or *larmes volcaniques*, are here plentifully found.

(*b.*) South of the margin of Laach.—On the south side of the lake, we find that, close to its margin, the sand is frequently

alternated with small dark coloured-cinders. More south, and at a greater distance from the edge of the water, the mixed lacustrine and tufaceous beds which have resulted from the overflow of moya from the crater of Rieden often appear undisturbed. They seem like small sand-hills. *(See Plate II. page 23.)*

(*c.*) South west of the margin of Laach.—Behind the abbey of Laach we find the following series of strata, which I give in a descending order:

a. Vegetable soil; (the uppermost bed three feet in depth.)

b. Sand mixed with some little tufa stratified and dipping irregularly. This appearance is probably the effect of some subsidence which had followed a volcanic disturbance of the contents of the lake.

c. Sand thrown up from the depths of the crater lake during volcanic convulsions, and greatly mixed up with volcanic cinders, among which I detected ellipsoid portions of trachyte.

(*d.*) West of the Margin of Laach.—On the west of the margin of Laach there is occasionally a sort of alternation produced between the sand thrown up and volcanic cinders. In one place small dark-coloured ashes, mixed with a sort of mud, occur to the depth of about nine feet.

(*e.*) North-West of the Margin of Laach.—As we approach to the north-west of the crater, we find the intermixture of tufa with the fresh water deposit of the crater lake to decrease, and the ejected lacustrine matter to consist more of the proper substance of whitish sand mixed with plastic clay.

The volcanic energy has been here particularly exerted. The fires rekindled in the volcanic focus, as well as the gaseous fluids extricated from it, have thrown up much lacustrine sand and clay, mixed with pumice and some fragments of volcanic and primary rocks,—though less of the latter than in other places. By these ejections the ridge of clay-slate intermediate to the ancient deep lake of Gleis and the Laacher-see, which had been the seat of an eruption of black basalt, slag and cinders, became covered with the matters ejected, and thus received an addition to its height. Its summit is known by the name of the Veitskopf. The previous basaltic eruptions of this hill I have before described. (See page 148.)

Among the accumulated mass of sand, mixed with plastic clay, characteristic of the Veitskopf, we trace trachytic pumice, cinders, and other fragments, in which many rare minerals have been collected. A peculiar felspathose rock (described in page 156) is here detected, as well as glassy felspar, containing Spinelle and Nosin. The pumice and cinders are of a whiter character than in other parts of the lake, and contain more Hauyne. Volcanic *bombs* are also found in this locality, and it is said that calcareous fragments are among the ejected substances here discovered.

On the east of the Veitskopf, forming what must be considered as a flank of the hill, we find a very considerable ejection of the materials of the lake, which consist of sand and loam; very little if at all mixed with tufaceous matter, but containing dark cinders and ashes. This we trace in a descent from the brim of the crater of Laach to the low ground of Wassenach.

(*f*.) THE NORTH SIDE OF THE LAKE.—On the north side of the Lake the bounding ridges of clay-slate become high and steep, and, as I have stated, there is so little evidence of this part of the crater having been disturbed by later eruptions, that patches of sand and plastic clay continue to be preserved perfectly unmixed with volcanic matter.

(*g*.) EAST SIDE OF THE LAKE.—The east side of the lake appears to have been free from later volcanic explosions, and the proper lacustrine deposit of the lake, consisting of plastic clay, has remained undisturbed, and is therefore worked with profit.

(*h*.) THE DISTANCE TO WHICH THE VOLCANIC SAND AND CINDERS OF THE CRATER OF LAACH HAVE BEEN EJECTED.—The grey volcanic sand which has been ejected by the lake owes its greatest dispersion to westerly winds assisted by aqueous currents, by which it has been transported a considerable distance, even to the foot of the Westerwald, where it forms a portion of the beds of this substance which have filled the basin of Neuwied. This sand, mixed with volcanic fragments, we trace covering the lava field of Mennig as far as Thur; we also trace the same at the foot of the Humrichs of Kretz, Kruft, and Plaidt; and as far as Nickenich, and between Eich and Andernach.

By southerly winds it has been transported very abundantly as far as Wassenach, or even to Tonistein, where lighter particles of pumice lie above the tuffstein of Bruhl.

South-westerly winds have transported the volcanic products of the crater as far as Kehl.

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After these details of the phenomena presented by the lake of Laach, it will, I trust, be apparent that the developement of its volcanism, which is supposed to have taken place at the dawn of the tertiary epoch, only reappeared, in the form of a series of minor eruptions, at the close of the self-same epoch, immediately antecedent to such important convulsions as were the precursor of that newer and later state of the earth's surface, which is recognized at the present day.

## CHAPTER XXII.

### THE VOLCANIC HILLS LYING TO THE SOUTH-EAST OF THE BASIN OF NEUWIED, WHICH RANK AS THE LATER ONES OF THIS DISTRICT.

THE volcanos, remaining to be noticed, appear to have broken out to the south-east of the general district which I have described. They consist of the Carmelenberg, and the smaller eruptions near it; of the groupe of the Saftig volcanos; of the groupe of volcanos named the Humrichs; and of the Nickenicher Sattel.

The whole of them, with perhaps the exception of the Carmelenberg, have a peculiarity which is not to be found among any others of the district. Their base, as is the case with the Humrichs, is either lined with a deep deposit of tufaceous mud, in which fragments of white pumice form a principal ingredient, or it is almost concealed beneath a deep covering of white pumice, with which, indeed, a considerable district around them is covered.

But it is of importance to add, that while the formation of the slag hills and craters themselves may be dated near the close of the tertiary epoch, the evolution of the fragments of pumice forms one of the series of later phenomena with which the present epoch was ushered in.

From these remarks, the convenience will readily be acknowledged of previously investigating these volcanos in their original character. The fragments of pumice with which they became subsequently covered, will form a subject of later inquiry.

### SECTION I.—THE ORIGINAL CHARACTER OF THE VOLCANIC HILLS LYING TO THE SOUTH-EAST OF THE BASIN OF NEUWIED.

In examining the structure of these volcanos we shall find, that they are either elevated into regular peaks, or slag hills, consisting of black, or brownish black slag, cinders, and volcanic sand, or that they exhibit regular crater walls formed of the same materials.

The oldest of these eruptions are the Carmelenberg and the small points of eruption contiguous to it, which probably date very near the time of the basalts which broke out around the margin of the crater of Laach. The remaining volcanic hills appear of a later date.

Our investigation will of course commence with the oldest of these eruptions.

#### *(a.) The Carmelenberg and the volcanos near it.*

The hill of the Carmelenberg (rather remotely situated,) lies to the south-east of the district which we are examining. It exhibits

a slag cone raised upon what was previously the rounded summit of a hill ridge, which, when the waters of the lake of Neuwied had maintained their highest level, amounting to about eight hundred feet above the level of the Rhine, was furrowed by the Moselle, which here became lost in the lacustrine expanse. This is shewn, as I have before explained, by the large accumulation of white pebbles existing at the northerly flank of the hill. But, when the present volcanic eruption took place, the level of the lake, and consequently of the river, was little higher than what is exhibited at present. The Carmelenberg may be therefore now considered as removed to the distance of two miles from the course of the Moselle.

The volcanic peak of the Carmelenberg is rather a considerable one, being elevated perhaps about two hundred feet above the level of the clay-slate hill from which it has been erupted. Its summit has been estimated at 1026 Rhenish feet above the level of the Rhine at Coblentz. *(See Plate VIII. view 1st.)*

The origin of slag cones, where the quantity of slag, volcanic ashes, or sand thrown out, much exceeds in quantity the gaseous fluids evolved, has been repeatedly discussed. All that it is therefore necessary to know with regard to the Carmelenberg is, that the peak of it is composed chiefly of very black or reddish black basalt slag, in which augite is contained, of cinders, and of volcanic sand.

Around the base of the hill there is a great quantity of black sand, in which magnetic ironstone, semeline and melilite, have been detected; but M. Steininger expresses a doubt whether the same has been ejected by the volcano of the Carmelenberg, or by some more northerly one, nearly contemporaneous. There are also several isolated basaltic blocks which appear at the north-westerly foot of the hill towards Octendung; but, as their site is intermediate to the commanding slag cones of Saftig, a similar hesitation about their origin remains.

The summit of the Carmelenberg, as well as the surrounding plain, is now so covered with wood, that its geology is rendered from this circumstance rather obscure. Towards the east a smaller slag cone is said to exist which I omitted to examine. It seems only to differ from that of the Carmelenberg in its reduced size. Connected with this is probably the lava stream of which M. De Wyck speaks. He states that it had a direction towards the Vanerkopfen, and that it appears under the subsequent covering which it received of pumice stone, volcanic sand, and marly earth. This stream is said to have afforded a quarry from which the bridge of Coblentz was built.

### *(b.) The Humrichs of Saftig.*

Other eruptions are situated about two miles north of the Carme-

lenberg, from which they are separated by a plain. They are commonly stiled the Humrichs of Saftig, from a village of that name, from which they lie a little to the south and south-west.

We here find that this groupe consists of not fewer than eleven slag hills named Humrichs. Of these, seven range from east to west;—the westerly one being contiguous to the basaltic flow of Werner's Ech. Other three range north-west of the most westerly one, while a last, or eleventh, appears due north from one of the more central Humrichs.—*(See the general Map.)*

Intermediate to these ranges of slag hills, there is a sort of deepening which occurs, conveying at a distance the impression of one large crater. Whether this depression actually indicates a crater or not, we have no proofs to offer. If the affirmative could be proved, its existence would rather be referable to the eruptions of pumice which occurred subsequently to the close of the tertiary epoch. (In Plate VIII. view 1st, this deepening appears in the more distant groupe of the Humrichs.)

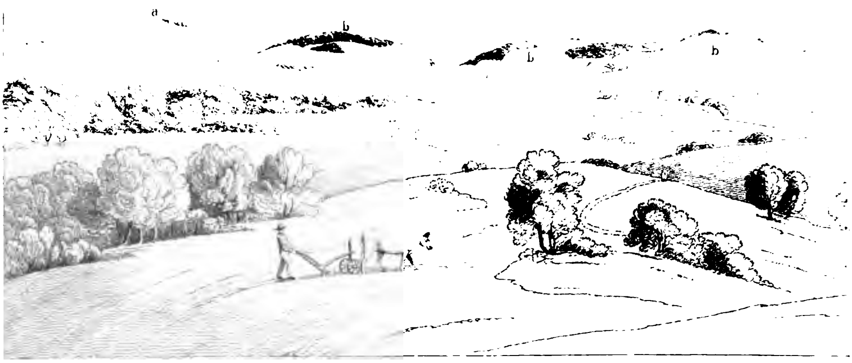
For these reasons I am inclined to suspect, that the Humrichs of Saftig, in their original state, can only be regarded as a groupe of slag hills breaking forth from an irregular fissure induced during some convulsion. The basaltic slag, cinders, or sand which they have ejected, do not differ materially from those of many other volcanos described, except that there is perhaps a little more of the action of fire evinced. The slag appears very porous, and near the Langenberg, which is one of the most westerly eruptions of the Humrichs, it is said to strongly affect the magnet.

It would seem that when these eruptions first appeared, this part of the basin was still in the state of a lake, but greatly drained. This is shown by the black sand ejected, which, having collected around the base of the cones, and having been mingled with the deposit of the nearly drained lake, has formed a sort of tufaceous mud, which is to be detected beneath the deep bed of white pumice, elaborated and given out during later volcanic convulsions. Certain deep sections exposed at Saftig show, that below the white pumice (which here attains a depth of two or three yards) are incoherent layers of dark-coloured tufa, which only lose their blackness from long exposure to the sun. In another place, again, we find the same lake-mud covered over with dark sand and ashes, while the whole is surmounted by layers of white pumice.

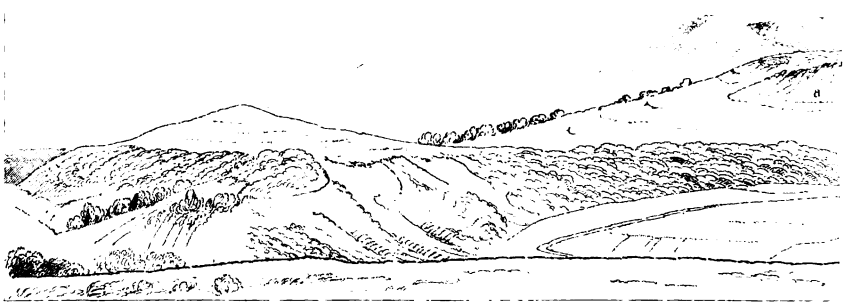
This eruption seems to have given out more than one stream of lava. Near the village of Saftig, the slag appears continuous for some small distance amidst lacustrine mud, so as to indicate a slight lava stream.

But the greatest lava flow is at Werner's Ech, which I shall next describe.

Plate VI




a *The Carmelen-berg* b.b.b. *The Humerich*




a *Humerich near Kraft.* b [illegible]

*Etched by W Percy*

The Zikenacher Sattel. Village of Eich.


...er Paudt Wernerseck

Drawn by Mr Aubert

*(c.) The lava flow of Werner's Ech.*

This lava flow appears to have broken out of the most westerly Humrich belonging to the Saftig groupe, the name of which is, I believe, the Langenberg. The hill whence it had its origin overhangs the valley which the stream of the Nette had then deepened. The lava flowed into it in a broad stream, abutting against high clay-slate rocks on the opposite side of the ravine, and causing the stream, in seeking for a new channel, to make a detour below the hill whence it had its origin.

The lava stream, thus collected in a narrow ravine, has been accumulated in the form of a small basaltic knoll. In following the flow from the south, we first meet with traces of it in some fields and gardens, through which the road leads to Plaidt, and, when we approach Werner's Ech, we observe faint marks of a prismatic structure.

The basalt shews in numerous parts of it slight marks of scorification.

The spot in which this eruption appears *(see Plate VIII. view 2d,)* is surrounded on three sides by water, which in feudal times, under the appellation of Werner's Ech, was selected as the convenient site of a baronial burgh or castle, which goes by the name of the Kelterhaus.

*(d.) The Humrichs of Plaidt, Kretz, and Kruft.*

These various Humrichs are found to the west and north-west of the Humrichs of Saftig, from which they are nearly divided by the stream of the Nette, and, in an opposite direction, they occur in the space intermediate to the two villages of Frauenkirch and Plaidt. On the north they are bounded by a stream, which, having its origin in the high ground near Obermennig, and the south of the Laacher-see, flows eastwards towards the village of Kruft, and then, making a northerly sweep, passes by Kretz and joins the Nette near the village of Plaidt. *(See Plate VIII. views 1st and 2d.)*

The materials of which these hills are formed differ in little or no respect from those of Saftig and other hills described. They consist of larger fragments of slag, or of cinders, which are of various tints. They are either deep-blue, brown, and black, intensely black, or reddish-black. They are often much burnt, or they turn yellow from decomposition. Upon these fragments a white efflorescence is often observable, which is most probably formed by the exhalation of various acids and alkaline matter, such as the sulphuric, muriatic, and carbonic acids, combined with soda and potash. In the slag some little olivine is to be detected, and small nodules of porcelain felspar.

Dark volcanic sand appears to have been given out from the Humrichs in extraordinary quantities.

It has been supposed by observers, that three craters are to be detected in these hills. M. Steininger describes a small round vent, like a crater, which may still be recognized, while a greater one, on the declivity of the hill, he thinks, ought to be more doubtfully admitted. This is probably the crater which M. Schulze describes. He represents it as open towards the east, and as giving out lavas which contain leucite, mica, and pyroxene.

M. De Wyck again speaks of a perfect crater at the Plaidter Humrich, which he even estimates at 585 paces in circumference. He conceives it to have been filled in, and rendered obscure, owing to substances washed into it by floods from the west.

All these appearances are certainly doubtful, although the great probability is, that at least two craters have subsisted in these hills, indicative of a considerable extrication of elastic fluids which took place during their formation.

With regard to THE PLAIDTER HUMRICH, it may, I think, be rather considered as a double than as a single volcanic hill, which exhibits two heads, the more northerly one situated above the village of Kretz, from which it is only divided by the stream that falls into the Nette near Plaidt, while the more southerly one appears to the west of the village of Plaidt, which is situated at the confluence of these streams.

The highest of these heads, near Plaidt, is a considerable slag hill, its height having been estimated at 725 Rhenish feet above the level of the Rhine at Coblentz.

[In Plate VIII. view 1st, the Plaidter Humrich forms the central volcanic elevation of the Humrichs, marked *b*, *b*, *b*;—and, in the 2d view of the same plate, it is separately marked *b*.]

The lava given out by this volcano, though much obscured by the falling in of slag, &c. or the eruption of later beds of pumice, is still to be detected. M. De Wyck conceives that the lava which has flowed out of the volcanic head, nearest Plaidt, which is the true Plaidter Humrich, extends to the basalt of the Rauschmahle.

THE KRUFTER HUMRICH lies to the east of the village of Kruft, from which it is divided by a small stream. It is usually described, though vaguely, as lying between the villages of Kretz and Kruft.

[In Plate VIII. view 1st, the Krufter Humrich is to the right of the groupe of the Humrichs;—while, in view 2d, it is distinguished by the letter *a*.]

There is, in this large volcanic peak, some little evidence of the extrication of elastic fluids having so far exceeded the ejection of slag and cinereous matter, as to cause a large crateriform opening, which, upon the cessation of the volcanic activity, became a crater-lake, and gave rise to other important phenomena, which will be related in an ensuing chapter.

To the south, or south-east, of the Krufter Humrich, a few slag knolls, perhaps three in number, appear. They are scarcely to be considered as forming a portion of this higher hill, but as existing independent of it.

*(d.) The Small Crater between Nickenich and Kretz.*

This very beautiful crater, likewise called a Humrich, rises from a flat plain, intermediate to the Krufter and Plaidter Humrichs, and the line of hills which we trace from the south-west of the Laacher-see to Eich. It is exactly intermediate to the villages of Kretz and Nickenich. *(See Plate VIII. view 1st, c.)*

The crater is known under various names:—When viewed from the south-easterly side, near Kretz, it is called the Plaidter Weg-kopf,—the road from Plaidt to Nickenich going round it upon this side;—while, in its appearance from an opposite direction, the circumstance of a part of its crater walls having undergone a breach in its height, and at the same time being rounded off in the form of a saddle, has suggested the name of the Nickenicher Sattel.—Lastly, it is named the Weinberg.

*The Nickenicher Sattel.*

It is rather remarkable that this crater, which is one of the best-marked ones in the whole of the basin of Neuwied, should not have been generally enumerated as such. From its vent there has evidently been a considerable disengagement of elastic fluids.

The materials of which the crater walls of this volcano are composed, appear much concealed by the deep covering of subsequent eruptions of pumice, the history of which must be postponed. But a very little attentive examination will shew that the

walls are composed of blackish or reddish-black basalt slag, and of cinders and black sand. Thus, at the foot of the crater, I found these substances exactly below the pumice, or pumice-stone dust, with which the crater was covered over. This is particularly shewn on the north-east side.—On the west side the slag rocks openly project.

The crater wall has been broken down on the north-north-east side from causes which it is difficult to assign. Owing to this breach, the interior of the crater is entered over fragments of pumice.

These slag hills and craters form the last which appear to have been developed in the basin of Neuwied. The only volcanic eruptions remaining to be noticed are those of pumice, which, in a later period, were ejected from old vents, and were dispersed over a considerable tract of country.

### Section II.—The commencement of the eruptions of Pumice yielded by the Humrichs, &c. dating from the close of the tertiary epoch.

It was at the close of the tertiary epoch that I am inclined to think all eruptions of basaltic slag, cinders, and black sand, similar to those which I have described, began to cease, and that a new species of eruption commenced, consisting of pumice, which was chiefly ejected from the fissures formed by previous volcanos, among the hills named the Humrichs.

The products which now began to be given out cannot but be regarded as simply the substance of lava, reduced either by a long continuance of heat, or by a more extraordinary degree of heat to the state of pumice. But under what circumstances this took place in the volcanic focus, is perhaps beyond the reach of our inquiry.

It is no less a curious fact, that the incandescent substance which appears to have been submitted to this extraordinary or longer continued heat, does not appear to have consisted of basalt, although ejected, with perhaps one exception, from craters which before had yielded little more than basaltic scoriæ, cinders, and sand. The materials reduced to this state of pumice either appear to have been a substance approaching to felspar, and resembling the grey-stone of Mennig, or to have been actually trachyte itself. This fact is shewn no less by the general character of the pumice, which resembles that ejected by trachytic volcanos, than by the glassy felspar which it contains, while its possible derivation from the grey-stone of Mennig is indicated by the numerous particles of Hauyne which it includes.

But this change of substance ejected cannot excite surprise, as

it has been found to be by no means unusual. Vesuvius has ejected materials at one time approaching to grey-stone or basalt, and at another to trachyte.

The pumice thus beginning to be ejected, which shews a felspathose origin, has the following characters:—

It is of a pure white, greyish-white, or yellowish colour, with a silky lustre.

It is remarkably fine, light, and porous, with a fibrous structure.

It is so light as to readily float upon water so long as its pores are dry;—but, as it is very absorbent, it sinks so soon as its pores are entirely penetrated.

It is frequently found to contain Hauyne in all gradations of colour, from its brightest sapphire tint to a degree of paleness by which it becomes lost in the substance of its base. The Hauyne is often seen in mere specks, or points, and, at other times, in portions as large as the fourth of an inch; but the latter size is comparatively rare.

Some fragments likewise contain minute crystals of glassy felspar, indicative, as I have remarked, of their trachytic origin.

Fine magnetic iron has also been detected in the pumice.

The size of the fragments of pumice which have been ejected varies much, from the dimensions of three or four inches to that of small grains, or even of pulverulent particles. Under this last form, which is an important one to be kept in view, it may be described under the name of *pumice-stone dust.*

The exact circumstances under which the pumice was ejected are rather obscure. As far as can be collected from the appearances presented, the ejection of fragments of pumice was a process effected less by one grand explosion, than by numerous reiterated ones, prolonged during a considerable interval of time. To this conclusion I am led by the proof which is afforded, that the pumice has in some instances escaped by comparatively small fissures, while, in others, the gaseous matter has been too inconsiderable in quantity to form for itself new and large craters, but has rather sought for disengagement through the medium of some ancient volcanic fissure. Hence the eruption of pumice, and its accompanying gases, through craters previously formed.

That the Carmelenberg, or some volcanic eruption adjoining it, has yielded some little pumice, appears probable from a section discovered in digging some deep sand pits between Coblentz and St Sebastian. Beneath the black volcanic sand which replaced beds of the plastic clay formation, the workmen arrived at a bed of the older gravel of the Rhine, below the surface of which, at a depth of eighteen feet, was observed a thin bed of pumice.

Hence it is not improbable, that this light substance had been ejected by the Carmelenberg, or some point of eruption adjoining it, and that floating down the Moselle it was eventually conducted to the site where it was found.

But far more considerable ejections of pumice took place from the Humrichs of Kruft, Kretz, Plaidt, and Saftig, or from the Weinberg of Nickenich, or from other sources remaining to be described, which have even been continued to modern times.

At present, however, it will be sufficient to state, that, at the close of the tertiary epoch, when still newer elevations of land were about to convulse the whole of the Lower Rheinland, eruptions of pumice had commenced from various fissures, the continuation of which, along with the later eruptions of the crater of Laach, form the volcanic features incidental to the commencement of the great diluvial catastrophe which followed, as well as the earliest period of the present geological epoch, which is properly distinguished from its predecessors as the historical epoch.

## CHAPTER XXIII.

### THE VARIOUS EARTHY OR MINERAL DEPOSITS WHICH SUBSISTED AT THE CLOSE OF THE TERTIARY EPOCH.

The series of events which we have related have at length brought us down to the close of the tertiary epoch. This chapter will therefore be dedicated to a consideration of the result of various processes, the commencement of which I noticed, whence certain earthy or mineral deposits were the result.

It is probable that by this time many of the crater lakes, which afterwards contained tufaceous mud, owing to the levelling of their barriers, were nearly or completely drained. To this more advanced state of drainage I would refer the craters of Rieden, Fusel, and Wehr.

The barrier subsisting near the present site of Andernach, by which the large lake of Neuwied had its waters originally preserved at a height of 800 feet or more above the level of the Rhine at Coblentz, was now so much worn down and reduced by disintegration, that the level of its waters was little higher than is manifested at present;—perhaps not more, (if I may be allowed, from various appearances, to form a conjecture,) than 150 feet above the level of the Rhine at Coblentz. Upon this supposition the lake of Neuwied would be greatly contracted; being on the south confined by the small ridge extending west by north from Coblentz

to Rubenach, Mulheim, Kaerlich, Kettig, and Eich, a distance of 13 English miles, while on the north its limits would be traced below the high ground extending from Ehrenbreitstein to Bendorf, Gladbach, and Nieder-Bieber, and thence south to the Rhine near Andernach. In extent it would be from 3 to 6 English miles from north to south, and from 4 to 13 miles from east to west.

That a flourishing vegetation then subsisted in the Lower Rheinland there are many proofs to show. It is in perfect accordance with the regulations of a provident Creator, that vegetable tribes should date their incipient abundance from the time when the numerous fresh-water lakes which had covered the surface of Europe were beginning to complete their drainage, and when a new and extensive soil was preparing for their spreading growth.

New races of animals were proportionally abundant. M. De Beaumont, in dividing tertiary deposits into two series, conceives, that while the former are characterized by the remains of such animals as the Anoplotherium and Palæotherium of Montmartre, the animals of later deposits, such as were contemporaneous with the period to which our history has arrived, consist of other species of the Palæotherium, of nearly all the species of the genus Lophiodon, of the whole genus Anthracotherium, and the more ancient species of the genera Mastodon, Rhinoceros, Hippopotamus, or Castor.

That many of these larger animals, and, probably along with them, MAN in his most savage state, ranged among the woods and marshes of the Lower Rheinland may be proved, less from the organic remains found in the basin of Neuwied, than from those of the lower valley of Cologne. The bones of vast animals are said to have been discovered at Eich, in the deposit which covers its lava flow, but the character of them has not, to my knowledge, been determined. From the travertine of Brühl we are certainly made acquainted that certain cervi were the inhabitants of the Neuwied basin, as well as the castor and the hare; while from other deposits we have no less satisfactory evidence of the existence of the squirrel, or one of the lesser feline species.

By this time, also, the greater part of the plastic clay and sand of the basin of Neuwied had been removed, and had undergone a distant transportation. It had been succeeded, or, in more precise terms, had been replaced, by three later formations. The first of these was the deposit, resembling the travertine of Italy, which had succeeded to removed beds of tuffstein in the trass valley of the Brühl, as well as the calcareous deposit of a few other localities;—the second was the gerölle or gravel, mixed in many localities with volcanic fragments of slag, with cinders, or with pumice;

—while the third was the black sand, resulting from numerous and nearly contemporaneous volcanos, which was deposited beneath the waters of the lake of Neuwied.

These various deposits I shall now describe in their order.

SECTION I.—THE DEPOSIT OF TRAVERTINE WHICH HAD SUCCEEDED TO REMOVED BEDS OF TUFFSTEIN IN THE TRASS VALLEY OF THE BRUHL, AS WELL AS THE CALCAREOUS DEPOSITS OF A FEW OTHER LOCALITIES.

The renewed interval of comparative quiescence from volcanic eruptions, to the conclusion of which we have at length arrived, appears to have differed in various particulars from a former one described. It may be considered as the latest of all tertiary periods to which M. Brongniart has referred his *Terrains Epilymniques*,—a period not only exemplified by the upper fresh-water beds of the Isle of Wight, but likewise by the ancient travertine of Italy, which in character not a little resembles the otherwise insignificant deposit of the same kind which was then taking place in the trass valley of the Bruhl.

During the rapid progress of disintegration to which the tuffstein of Bruhl became subject, large cavities soon indicated the removal of very deep portions of the upfilling mass. These depressions had their chief site a little to the north of Tonistein, where the stream which was directed from west to east, namely, from the westerly heights of the Hahnenbach to the trass valley of the Bruhl, met another which had its source in hills adjoining the Laacher-see, with a direction from south to north.

Owing to the collision of these two streams running from different sources and in opposite directions, we can easily conceive, that, at their point of collision, the tuffstein subjected to their action would exhibit deeper and earlier states of corrosion. The concavities thus formed soon became, in their turn, the site of small pools, and of still newer operations. Springs holding the carbonate of lime in solution issued from the depths of the channel of the Bruhl, and began to deposit the matter with which they were fraught in these depressions. Accordingly, near the present site of the mill of Tonistein, the deposition of calcareous beds had commenced.

In the character of this deposit some varieties are discernible, particularly at the confluence of the two streams. Thus, the stream which pursued its course from north to south would carry along with it disintegrated particles of tuffstein, which, in finding a lodgement in concavities, then in the process of being filled with travertine, would present the form of calcareous and tufaceous alternations.

In other instances fragments of pumice have been found in the calc-tuff.

But these beds of travertine are the most interesting for their containing memorials of the vegetable and animal races which then began to exist. Into the valley of the Bruhl leaves and branches of trees, terrestrial and fluviatile shells, as well as the bones of mammalia, were washed, and, having been intercepted, remain inhumed within this calcareous deposit.

Various notices of the organic remains which have been found in the travertine of Bruhl have from time to time been published, but it is not always easy to distinguish such as are referable to the dawn of the modern, or historical period. As many animals, however, are common to both periods, having survived a diluvial catastrophe which swept over a considerable portion of the Lower Rheinland, the distinction ceases to be an important one.

Among the remains of the mammalia inhumed in the travertine of Bruhl, there has been discovered the bones of the castor, a malar bone of a stag, the jaw and femoral bone of the hare, and the incisor of an animal not yet identified. The shells detected in it are the Helix pulchella, succinea, and oblonga; the Lymneus ovatus and a Bulimus. Lastly, impressions of leaves resembling those entangled in the tuffstein of Bruhl have been found in the travertine.—(For various notices regarding the organic remains found in the valley of the Bruhl, the works of M. Steininger may be consulted.—See also Cuvier's *Ossemens Fossiles*, Vol. v. part 1st, p. 55.)

The travertine of the trass valley of the Bruhl may be regarded as the only deposit in the basin of Neuwied entitled to attention. Very slight calcareous depositions may be traced in other places, as at Kottenheim, and in the clefts or hollows of the lava of Mennig;—whence the volcanic origin which in this last locality has been ascribed to them.

### Section II.—The Gerolle, or Gravel, mixed in many localities with volcanic fragments of slag, with cinders, or with pumice.

In before treating of the commencement of the deposit of gerolle, or gravel, it was remarked, that along the course of the Rhine, and of the lakes formed by it during its course, there must necessarily have been a number of minor collections of water where the process of drainage would in some degree keep pace with that of larger lakes. Emptying themselves, therefore, one after another, such sudden inundations would necessarily drag along with them earthy and vegetable matter, and even animal remains, along with large stones and boulders; which deposit would in many places fill up the voids occasioned by the removal of the

prior lacustrine deposit of fine quartzose sand and plastic clay contained within the basin.

In conformity with this view we ought to expect that the river Gerolle, or Gravel, would line the declivities of the ancient margin of the lake of Neuwied, particularly where streams had emptied themselves into it, and would thin off gradually towards the depths of the lake. So many illustrations of this familiar fact are exhibited around the margin of the tertiary lake of Neuwied, that it is almost unnecessary to particularize them. Near Coblentz, not far from the confluence of the Moselle, we find, resting upon the clay-slate, alternations to a great depth of gravel and sand, the whole of which is surmounted by pumice, or alternations of pumice and sand. Near Mayen, we find resting upon plastic clay and sand the beds of gerolle or gravel by which this older deposit was replaced. At Bassenheim and the Rodderberg, and various other places, either beds of gravel, or gravel mixed with loam, subsist.

The minor vallies connected with the Rhine likewise appear to have been much filled up with gravel. For instance, in crossing the ground between Namedy and Kehl, a great deposit, formed during the damming up of this ravine by the tuffstein of Brühl, has ensued, consisting chiefly of fragments of clay-slate, which lie thick upon the declivities of the valley. In another site I saw the same deposit mixed up with some little volcanic and vegetable matter.

Upon the lava field of Kottenheim and Mayen, which is situated in the midst of volcanic eruptions, a great deposit of volcanic debris appears to have taken place to the depth of 30 to 40 feet, which chiefly consists of volcanic products mixed with some little gravel, resulting from the disintegration of rocks of clay-slate. Rounded pebbles of basalt slag, together with cinders and pumice, with tufa, or with loam, form its chief character. In the same deposit the remains of an animal of the feline genus are said to have been discovered.

But the most interesting deposits, referable to the gravel in which volcanic fragments enter as an ingredient, consist of those which we find above the lavas of Mennig and of Eich. These we shall separately consider.

### *The deposit of Gravel and of Loam mixed with volcanic matter above the Lava of Mennig.*

The lava flow of Mennig has been described in the eighteenth chapter of this memoir. *(Page* 116 *to* 125.*)* It occurs in the plain of the Maifeld, where two villages appear in its course, the one, Obermennig, situated to the west of it, and the other, Niedermennig, in a central site. Its extent, which must be considered as very irregular, may from north to south vary from one to two

English miles, while from east to west it may perhaps be estimated at two miles.

Much of the deposit resting upon the lava may be referred to drainages of the higher lands south and south-west of the Laacher-see, as well as to drainages east of the crater of Rieden. Hence the fragments which we observe of clay-slate, of trachyte, or of basalt, as well as the mixed debris resulting from broken up beds of plastic clay, sand or tufa. Other materials, again, would be derived from the district of the Hoch Simmer, and hence the great proportion of fragments of basalt which we observe in the same deposit, either in a lithoid, slagged, or cinereous form. Lastly, extraordinary floods would swell the deposit with debris from the more distant hills of clay-slate bordering on the Langenfeld.

Keeping these sources in view whence the fragments were derived, and the very miscellaneous character of their mineralogy, we can scarcely be surprised at the varied nature of the gravelly deposit. An accumulation of gerolle, or gravel, is superimposed upon the lava flow, wherein a variety of rolled fragments is evident, the cement of which is an earthy trassy substance, of a mixed loamy and arenaceous character, which is derived from tufa, as well as from lacustrine deposits of sand and plastic clay. This commixture seems the result of powerful torrents, but, where the force of the waters has been occasionally intermitted, we find a corresponding quiescent state indicated by alternations of the trassy loam described, which is variously named by the natives Britz Reif, mould, or old soil. This last substance has been described by M. Steininger as a fine pulverulent or sandy deposit of a grey or pale colour, which is stratified and alternated with pumiceous matter. It is also recognized as forming the soil of many localities near the Hoch Simmer, or the Laacher-see.

In this deposit, animal as well as vegetable remains have been discovered. Spaces are said to have been noticed in the gerolle, or gravel, in which the bark of trees and impressions of leaves, along with a grey substance resembling the ashes of plants, have been occasionally found. In the year 1798, a tree, supposed from its rind to have been an apple-tree, was found in a perpendicular position in the deposit which rests over the lava of Niedermennig. Bones of animals have likewise at various times been discovered.

But we shall now consider in detail the different beds which form this deposit.

Sections of the lava of Mennig have been before given. Some geologists have not been content with referring organic remains to the deposit which is superimposed on the Mennig lava, but have even entombed living ones in the congealed flow. M. Steininger recorded the asseveration of the workmen, that they had found a

living toad immured in the millstone lava,—but I now find from the report of M. Schulze's memoir, given in the "Journal des Sciences Naturelles," that the single toad is at length multiplied, (after the well-known precedent of the three black crows,) into *three* living toads! The exact situation assigned to these ancient hermits, it may be perhaps worth while to give. It will be found in the following section in a descending order, which rests upon the authority of M. Schulze:—

(*a*.) The uppermost bed consists of about 100 feet of loose volcanic matter, and ancient and modern alluvium;

(*b*. The bed, upon which this alluvium rests, is described as prismatic lava, 36 to 42 feet thick, while beneath it is a bed of reddish-grey porphyritic basalt;

(*c*.) 10 feet of "lave fendillée," *in which three toads are said to have been found;*

(*d*.) $2\frac{1}{2}$ feet of lava and scoriæ;

(*e*.) Clay, (the lowest bed stated,) which high up is sandy.

It is unfortunate that the actual discovery of living toads thus immured has not yet encountered the vigilant and cautious superintendence of scientific individuals. The records of them hitherto published are little more satisfactory than so many *on dits*.

The beds covering the lava of Mennig have been frequently described, but by no two authors alike. I shall give an abstract of M. Noeggerath's observations, which seem to me to have been conducted with the most care:

*a*. Gerolle, consisting of fragments of grauwacke and clay-slate, as well as quartz, and even portions of barytes, together with volcanic fragments;—the whole cemented by a pulverulent mixed substance of trass, sand, and clay.

(*This upper bed I am inclined to suspect is partly a diluvial one*. Its depth is 14 feet.)

*b*. *Britz Reif;*—a mixed pulverulent substance of trass, (tufa,) sand, or clay. It is sometimes called black rich earth. Animal remains are found in it. Its depth is 8 inches.

*c*. Gravel, like *a*; 34 feet.

*d*. Britz Reif, like *b*; $2\frac{1}{2}$ to 3 feet.

*e*. Loose porous volcanic nodules, formed of the substance of the lava called *Mucken*;—12 feet thick.

*f*. Irregular colossal pillars, the depth of which is unknown.

A different section, however, is given by M. Schulze, which I have extracted from a French journal. It is as follows:

1. Pumice and trass covering the lower beds, 40 feet thick.
2. An aggregated deposit of porous lavas, basalts, and cinders, the depth of which is 10 to 12 feet.

*(These two superior beds, I am inclined to think, are partly diluvial, and partly of a comparatively recent period. They will be referred to hereafter.)*

3. Sandy marl, in which vegetable and animal remains are found;—thickness 6 to 10 inches.
4. Schistose clay, ½ to 1 foot.
5. Volcanic matter 50 feet.
6. Prismatic lava, 36 to 42 feet thick.

*(The beds still inferior have been given in the preceding page.)*

These two sections it is rather difficult to quite reconcile to each other, and unfortunately I myself made few independent observations, for which, indeed, I had not opportunity, as M. Noeggerath's observations were conducted during the course of mining operations.*

According to M. Schulze, it is in the bed of sandy marl six to ten inches thick, corresponding probably with M. Noeggerath's *Britx Reif*, (the latter being perhaps the most correct description of it,) that impressions of leaves and grasses, as well as the roots of trees, have been found, and, together with them, the remains of various animals, among which are those of Cervi, with the teeth of the squirrel.

Regarding the supposed indications of an early race of human inhabitants of the soil of the Lower Rheinland, the greatest caution is necessary, though I am far from thinking it impossible that unequivocal remains, shewing that a very early race of mankind did then exist, may not yet be satisfactorily produced. In the meantime, I shall content myself with a mere notice of the supposed discoveries, given on the very fallible authority of miners, which are introduced in M. Schulze's memoir. It is said that in the beds superjacent to the lava of Mennig ancient baked potteries have been found surrounded with scoriæ, and even a bunch of straw with a string attached to it!—("Bulletin des Sciences Naturelles," A.D. 1831, page 11.)

The same geologist also speaks, I presume on the authority of workmen, of a portion of lead having been discovered in a fissure of the lava filled with alluvial marl.—But I am wearied with repeating the gossiping stories of credulous miners.

### *The deposit resting upon the Lava of Eich.*

The lava flow of Eich has been explained in the nineteenth chapter of this memoir.—(*See page* 127.) Its exact point of ori-

* I rather suspect that the distinct beds marked *c, d, e,* in the section of M. Noeggerath, are included in the one marked *5* in that of M. Schulze; and that the bed marked *b* of M. Noeggerath contains the two marked 3 and 4 of M. Schulze.

gin is unknown. It has evidently flowed into the lake of Neuwied, and become submerged beneath its waters, where it has afforded a basis for an interesting deposit now to be noticed.

This deposit is well displayed in the Neisbusch stone-quarries, where there is to be seen the following section:

(*a.*) The higher beds, consisting of alternations of loam, white pumice, and vegetable soil, to the depth of 27 feet or more. These I must consider as of a comparatively recent date, and they will be considered in detail hereafter.

(*b.*) A deep bed of argillaceous loam, from 18 to 20 feet in depth, in which are contained fragments of lava, cinders, and tufa.—*This bed is the object of our present consideration.*

(*c.*) A very porous and scorified basalt slag, which preserves this character for a depth of 15 to 18 feet; below, for a thickness of 24 feet, I found it more compact;—the sum of its depth is unknown.

The argillaceous loam which appears in this section is the deposit of the close of the tertiary epoch, which may be referred for its constitution to removed materials of the plastic clay formation, to removed strata of early tufa, and to the ejected products of neighbouring volcanos.

In this clayey loam, which is of a dark yellowish-brown colour, large bones are said to have been found; but the nature of them has not, to my knowledge, been recorded by any writer.

## Section III.—The Volcanic Sand deposited in the Lake of Neuwied.

This deposit of dark-coloured volcanic sand, which is a peculiar characteristic of the Maifeld, is one that might have been expected as the natural result of a succession of volcanos, which had been carried on with undiminished energy for an almost indefinite period of time. It was deposited beneath the waters of the basin of Neuwied during the course of all the great eruptions which took place since the period of the trachytes and early basalts.

"The black sand of the Maifeld" was, as we may conceive it to have been, carried down by mountain streams soon after having been ejected. Such as the Nette had transported would, from its great accumulation, soon supply the vacant space occasioned in the nearly drained basin of Neuwied by the removal of much of its prior deposit of sand and plastic clay.

The mineralogical character of this loose sand, owing to its origin from so many volcanos, must naturally assume a very miscellaneous character. It has been examined by German geologists with much attention, who have detected in it the following ingredients:—Particles of porous basalt, whence the name which

the whole has received of the black sand; augite; titaniferous magnetic iron ore; pumice-stone grains, and basaltic hornblende.

An analysis of the sandy magnetic iron ore has been given in M. Von Leonhard's Taschenbuch.

| | |
|---|---|
| Iron, - - | 79.0 |
| Titanium, - | 15.9 |
| Oxide of manganese, | 2.6 |
| Alumina, - - | 1.– |
| Trace of chromic acid, | |
| | 98.5 |

We find this deposit in the vicinity of Gladbach lying very deep. From subsequent convulsions, its strata are much inclined, and dip towards the mountain of Romersdorf.

## CHAPTER XXV.

### THE DILUVIAL CURRENT WITH WHICH THE TERTIARY EPOCH WAS CLOSED.

The great incident which in the Lower Rheinland marked the close of the tertiary epoch was the diluvial torrent, which, in deriving its origin from the convulsive operations which were directed to the elevation of the high chains of the European Alps, bent its course along the great valley of the Rhine, and again raised the waters of the basin of Neuwied to their ancient level.

But it is unfortunate for this part of our history, that, if we would understand the interesting phenomena connected with this diluvial current, it will be expedient to take a rather discursive view of the general state of the Upper Rheinland from Mayence to Basle, as it subsisted at the close of the tertiary epoch.

Some part of the history of the valley of the Upper Rhine I have before had occasion to explain. According to the recent speculations of M. Boué, it has been supposed, that, previous to the deposition of the Molasse of the continent, the marine waters which flowed over much of the present soil of Europe had their connection with the main ocean cut off, and that a large inland sea existed to the north of the Alps, which extended from the Savoy to the Bannat, while, on the north, it was separated from the Baltic by the Carpathian and other mountains.

This inland sea has been already described as having been divided by the irregularities of the encroaching land into six or

seven basins, one of which was the valley from Mayence to Basle. Of this marine basin I added, that, in consequence of a barrier of land stretching across the present site of the straits of Bingen, and thus filling up the small geographical space intervening between the chains of the Hundsruck and the Taunus, it had no communication with the present channel of the Rhine from Bingen to Cologne, or farther north;—that its waters flowed in a direction quite opposite to that which they now maintain, being from north to south, while its southerly extremity was connected with the other marine basins of Europe by means of various channels.

The gradual changes by which many of these marine depressions were filled up have met with an able illustration from M. Boué. He has supposed that the waters poured upon the earth must have been so great, that the debacles of modern lakes and the excavations of equatorial rivers can convey but a faint idea of their effects; and hence the levelling of much of the depressed surface of Europe would be comparatively a rapid process, of which the marine basin of Mayence would be one of the first to partake.

After the deposit of the Molasse of Europe, (so named from the blue clay which is its characteristic, and of which the miscellaneous local deposit of the basin of the Upper Rhine may be considered as an equivalent,) had greatly accumulated, it may be easily supposed that the relative state of land and sea in the interior of Europe would be materially altered. In consequence of a great portion of the materials which formed this deposit having been transported by the rivers of the Alps, the chief current of this inland sea would be urged or directed more to the centre of the great concavity of Europe. It would also happen, that, owing to many of the canals, by which these various marine basins communicated with each other, having been blocked up by the deposits carried into them either by rivers, or by the bursting of lakes, the waters would now seek for a discharge by new issues, and, as a consequence, the previous number of seven marine basins would be multiplied.

With respect to the upper basin of the Rhine, which, among the great inland seas of Europe, had a detached situation, the blocking up of the narrow canals by which it communicated with more southerly basins appears to have had the effect of completely changing the nature of its deposit. We accordingly find, that Neptune did not continue to assert his dominion over this Caspian lake;—that although alternations of marine and fresh water beds, severally calcareous, and even intermixtures in the same strata of terrestrial, fluviatile, and marine shells had long since showed that his sovereignty was disputed; yet that now, if we

may judge from the predominance of the fluviatile beds which overtopped the series, the mountain nymph and river gods were eventually triumphant.

That a pure fresh water deposit was the latest result of the upfilling process then going on in the basin of Mayence, we are not so adequately informed by any relics of it having been found *in situ*, as by the immense transported and detached masses of it which remain as memorials of the extraordinary and extensive convulsion which I have proposed to describe. In the meantime, it will much facilitate the order of our history by previously inquiring into the original character of this deposit.

The latest tertiary deposit which appears to have characterized the valley from Mayence to Basle has been properly considered by M. Boué as the product of a great fresh water sea that filled the whole basin of the Upper Rhine. It has been described under various names, of which the one most adopted is that of *Loess*. According to M. Von Leonhard, its synonyms, as they occur along the course of the Rhine, are Loesch, Schneckenhausel-Boden, Mergel, (in the upper lands of Boden,) and Briz. By M. Steininger and some other writers the deposit has been variously named Britz, Lehm, or it has met with an appellation significant of a yellow marly earth. M. Boué styles it an alluvial fresh water marl.

This very fine pulverulent substance became first deposited when the causes which had produced the deposit of gravel arising from the bursting of contiguous pools or lakes, accompanied by the deluging actions of rivers, appear to have ceased;—which state of quiescence we may refer to the abatement of those convulsive operations with which our globe had been so long familiar. Hence the finer particles of earthy matter, the result of a more gradual and uniform operation of less destructive rains, became more equally diffused through the waters of a vast lake, and, on their subsidence, were deposited over previously existing beds of ancient gravel,—the records of a more disturbed condition of the earth's surface.

The Loess, which, as I have explained, formed the highest bed of the tertiary deposits of the valley of the Upper Rhine, has been described by M. Von Leonhard as consisting of fine pulverulent particles connected together in a loose friable mass; or as a loamy substance, of a dirty yellowish-grey colour, and in its fracture earthy, being a mixture of particles of argillaceous, calcareous, and quartzose matter, in which are interspersed minute scales of mica.

It is added by the same author, that in the Loess of the vicinity of Heidelberg were found four proportions of argillaceous matter, combined with one of carbonate of lime, and a sixth proportion of quartzose and micaceous sand.

Numerous organic remains have been discovered in the Loess; but, as it is difficult to draw the distinction whether all of these originally existed *in situ*, or were entangled in this deposit during its subsequent violent transportation, I shall postpone a description of them, until I have noticed the breaking up of this deposit and its distant removal.

From the circumstances described it will be evident, that the basin of Mayence was eventually reduced to the state of a fresh water lake, characterized by a later deposit of Loess. The overflow from it, after it had ceased to admit the waters of the inland sea, of which it had previously formed a portion, was still conducted into the marine expanse which subsisted in the central regions of Europe.

At the close of the tertiary epoch, when the fresh water deposit which I have described had attained a considerable thickness, the surface of Europe was doomed to undergo a greater change than it had experienced since the elevation and breaking up of the chalk basins.

In the basin of Neuwied this catastrophe took place at the time when ejections of pumice from the Humrichs had commenced, and when the latest eruptions from the crater of Laach were in activity. It was the effect of a distant elevation of high alpine lands situated near the outlet in which the great fresh water lake, extending from Mayence to Basle, was enabled, in flowing in a southerly direction, to discharge its waters into the inland sea of Europe;—that is, in the vicinity of the lake of Constance.

To what recognizable convulsion this particular elevation of the great alpine lands of Europe is to be referred, which in the basin of Neuwied is only made known to us by its diluvial ravages, I scarcely think we have yet sufficient data to determine. A considerable elevation of the Western Alps is described by M. Elie de Beaumont, who assigns to it a date immediately subsequent to the very recent beds, named *Shelly Molasse*,—beds contemporaneous with the Fahluns of Touraine. He also supposes it to have taken place in a direction of N. N. E. and S. S. W. But subsequent to this catastrophe, he adds, there has been a later dislocation, (the twelfth of his system,) which elevated the principal chain of the Alps from the Valais to Austria, comprising also the chains of the Ventoux, the Liberon, and the St Baume, (Provence.) The direction of this system of mountainous elevation he conceives to be about E. $\frac{1}{4}$ N. E. and W. $\frac{1}{4}$ S. W., and he ascribes to it a date previous to the dispersion of those erratic blocks, and those gravels which have been termed *diluvium*. (*See the Philosophical Magazine for October* 1831, p. 257, *and Mr De la Beche's Geological Manual*, p. 499.)

It is probably to this last system of elevations that the diluvium, whose devastating progress we trace through the whole of the Rheinland, may be referred.

A subordinate question may, however, arise, whether the latest elevation of the alpine heights of Europe was exactly an instantaneous process, produced like the single paroxysm of an earthquake, or whether this latest elevation was not acquired by dint of a series of throes or convulsions continued during an interval of time, which, though a short one in geological estimation, would be considerable when compared with an historic term?

I am certainly myself inclined to think that the convulsion was a sudden one, and that, in comparatively a brief interval of time, the alpine mountains of Europe sustained an increased elevation, and that, along with this increase of elevation, a vast additional surface of land appeared above the primeval seas.

That the basin of Neuwied partook in some small degree in this convulsion there can be no doubt; though it is not in most instances easy to separate the phenomena indicative of a change of level which this part of the Lower Rheinland must have sustained, from previous phenomena of a similar character which occurred when the chains of the Hundsruck, the Taunus, and the Eifel sustained an elevation (*see page* 90.) In one instance, however, the appearances seem unambiguous. The deposit of the black volcanic sand in the basin of Neuwied is supposed to have taken place subsequently to the former convulsion,—and, accordingly, on the right bank of the Rhine, near Gladbach, I found strata of black sand much inclined, and dipping to the east or north-east, towards the hill above the village of Romersdorf. In this later dislocation of the strata of the basin of Neuwied, there is little doubt but that such older tertiary deposits partook, as I have supposed to have been affected by the earlier convulsions.

The catastrophe by which the alpine mountains of Europe sustained an increased degree of elevation appears to have comprehended various incidents, which I shall now endeavour to trace.

The first incident following the elevation of the European Alps consisted in the inversion of the current of the basin of the Upper Rhine, by which, instead of flowing from north to south, it began to flow from south to north.

A second incident was the immense force possessed by the volume of waters, which was propelled in a new direction of south and north, namely, from the basin of the Upper Rhine to the basin of the Lower Rhine.

A third incident was the new channel which the waters had begun to deepen for themselves through the present straits of Bingen.

A fourth incident was the distant transportation of loose stones and blocks.

A fifth incident was the breaking up of the upper fresh water strata of the Loess, with its transportation and dispersion to various sites along the course of the diluvial torrent.

A sixth incident consisted in the mineral substances entangled by the Loess in its course.

A seventh incident was the overwhelming of forests, and the great destruction which befel many races of animals during the progress of the diluvial torrent;—while

An eighth incident (which confines our attention rather more to the basin of Neuwied,) was the blocking up which the rapid transportation of the muddy volumes of Loess appears to have caused in the gorge of Andernach, and by the restoration which followed of the ancient high level of the waters of the lake.

These various incidents we shall now investigate in the order which has been stated:—

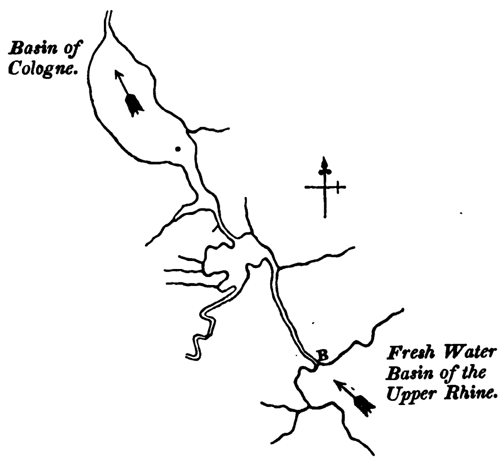
### Section I.—The inversion of the current of the basin of the Upper Rhine, by which, instead of flowing from north to south, it began to flow from south to north.

The last elevation of the European Alps, which was the most considerable in the vicinity of the lake of Constance, appears to have effected a change in the level of all the districts which we trace along the valley of the Rhine extending from Basle to Bingen, and perhaps even beyond the ancient barrier of Bingen, as far as the basins of Neuwied and Cologne;—all this tract of country acquiring a new elevation, which must have gradually diminished in proportion to the distance of each elevated part from the vicinity of the lake of Constance, where the elevation would be the greatest.

The consequence of a continuous declivity having been thus formed along the united course of the vallies of the Upper and Lower Rhine, is best seen by a reference to the geographical sketch, which I have before given, illustrative of the tertiary geography of the Lower Rheinland:—

Now, by reference to this sketch it will be evident, that the waters of the ancient marine basin of the Upper Rhine, (now converted into a *fresh water lake,)* had originally flowed from the present site of Mayence to Basle in a direction of north and south, towards the great inland sea of Europe;—this is indicated in the sketch by an arrow: while, on the other hand, the direction of the streams north of the basin of Mayence, which was towards the basin of Cologne and the German Ocean, is indicated by another arrow pointing to an opposite course, namely from south to north.


But we must now change the direction of the arrow, as it appears in the ancient marine basin of the Rhine, making it no longer turn from north to south, but from south to north; or, in other words, the arrows of the basin of Mayen, and of the basin of Cologne must be directed to the same destination, after the manner which is represented in the following outline:—




In this sketch the letter B signifies the site where the waters, in descending from the basin of the Upper Rhine, rushed into the channel of the Lower Rhine at Bingen.

But although the general course of the diluvial current was from south to north, it may be necessary to observe that some modifications have been observed in this direction of the rush of waters, which are in fact to be expected. The resistance which the current would undergo in its course from opposing cliffs and mountains, or from the narrow ravines in which it would be occasionally straitened, would occasionally cause a considerable diversion from the general course of the diluvian course, so as to induce it in some localities to rush, not from south to north, but in rather different directions. Accordingly, near the Schwartzwald, the course of the debacle is said to have been traced from east to west, though this remark stands in great need of confirmation. Again, in other sites, as in some few parts of the basin of Neuwied, the diluvial current has proceeded from south-east to north-west.

These are subordinate circumstances, which have led some few observers to serious errors in their views of the diluvial phenomena of the Rheinland.

In short, the sum of the change effected by the elevation of the European Alps was as follows: The waters of the upper fresh-water basin of the Rhine, which had originally flowed from the present site of Mayence to Basle in a direction of north and south, towards the great inland sea of Europe, must now have suddenly changed their course from south to north, and, in escaping across the barrier of Bingen, where a cataract of the most formidable and overwhelming character must have been formed, would eventually press forwards towards the inferior basins of Neuwied and Cologne, and thence to the ocean, which then covered the present flats of Holland.

### Section II.—The immense force possessed by the volume of waters propelled in a new direction of south to north, from the basin of the upper to the basins of the lower Rhine.

The explanation which has been given will prepare us for a due estimation of other effects indicative of the convulsion by which the southerly valley of the Rhine became much more elevated than the northerly one, and by which, as a consequence, the direction of the current of waters occupying the upper basin became inverted, so that, instead of flowing south, as formerly, towards the ancient inland sea of Europe, it was now flowing north towards the barrier of Bingen, the lakes of Neuwied and Cologne, and ultimately towards the present German Ocean. This altered current became fraught with all the waters derived from the Vos-

ges and the Schwartzwald, as well as from the newly elevated alpine heights, which, by the last uplifting agents, had advanced into the regions of perpetual snow.

In a preceding chapter (page 90) I inquired into the less violent effects which appeared to have resulted from a former diluvial torrent, occasioned by a slight elevation which the chains of the Hundsruck, the Taunus, and the Eifel, had experienced. But we have now to consider the effects of a torrent in its most tremendous and terrific career, when the process by which the Western Alps became elevated was near its completion.

If we suppose that, in the former diluvial instance cited, (see page 90) the comparatively less violent effect of the diluvium arose from the little elevation which the hills whence the Lower Rhine derived its source, had experienced, as well as from the little increased descent which the current of its waters had undergone, the next question which might be asked is, What would be the effect of an elevation of distant Alpine lands, sufficiently great to cause the whole body of the waters contained in the upper valley of the Rhine, to be discharged along the channel of their inverted declivity towards the present German Ocean?

These effects will be found so immense and striking, that another question which may eventually be started is,—Are the waters which were contained in the basin of the Upper Rhine, when existing in the form of a lake, of themselves adequate to produce the effect?

To such a question it is not easy, in the absence of any processes at present going on of so stupendous a character, to give a decisive answer. Lately, geologists have been disposed to call to their aid an additional source of diluvial waters, by supposing that vast cavities subsisted beneath the surface of the earth, into which large volumes of water, during extraordinary convulsions, or during their retiring, might have entered, or into which the waters of lakes might have gradually percolated.

Accordingly, such a collection of waters has been conceived by a French geologist, M. Rozet, to have existed within the interior of the chains of the Vosges and the Schwartzwald.* He has also imagined, that, while the waters were thus immured within their subterranean recesses, they must have derived from laboratories concealed within the profundities of the earth various chemical properties, among which none were more remarkable than their being charged with carbonic acid. At the period, therefore, when convulsive operations commenced, these acidified waters are

* I may here remark, that a modern instance of water which at the time was suspected to have issued out of a mountain, is to be found in the Annual Register for A. D. 1788, p. 77 and 78.

bances, or elevation of alpine mountains, by which the current of the Upper Rhine was becoming inverted, did not, in the first instance, appear to have displayed all their violence. But this remission, or perhaps intermission, was of brief duration. It was soon succeeded by a diluvial torrent, which in its course surmounted every obstacle.

### Section III.—The passage which the waters, in their inverted course, appear to have deepened for themselves through the present Straits of Bingen.

Although, in the period preceding the diluvium, the barrier of land which stretched across the present site of the Straits of Bingen was sufficiently high, a considerable breach intervening between the chains of the Hundsruck and the Taunus must have still subsisted, though not sufficiently deep to allow the waters of the upper basin of the Rhine to drain off into the present channel of the Lower Rhine. This intervening space may, I conceive, be dated from the early convulsions by which the much deeper fissure of disruption was induced, which, commencing at a northerly point close to the barrier of Bingen, only ended at Coblentz, or even farther north.

When these previous circumstances are taken into consideration, I can conceive of no other effect that the diluvial torrent would have, than by further deepening a breach which had previously been made. During the first inverted rush of the waters the swell would surmount the barrier of Bingen in a bold and appalling descent, and a considerable wearing away of the substance of the opposing cliff would be the result. But, if we would wish to explain the causes which have reduced the loch of Bingen to the depth which it exhibits at the present day, we must subjoin to the force of diluvial currents, the gradual and long corrosion of the Rhine, which, during the present geological epoch, has succeeded to this extraordinary agency.—Human art and labour, in the attempts to facilitate the present navigation of the Rhine, have achieved the rest.

### Section IV.—The Distant Transportation of blocks, or boulders, and gravel.

If we would investigate the extent of this diluvial incident, we ought to previously possess some knowledge of the general and older formations of the Upper Rheinland, from which the stones, blocks, and boulders, transported by inverted currents, are derived. In this limited memoir, any particular explanation of the geology of the Upper Rheinland is out of the question. All that I shall therefore attempt is a brief glance at the rocks which subsist in the valley from Bale to Mayence.

The valley from Bale to Mayence is bounded by the Vosges and the Schwartzwald. In the great chains of these mountains are found granite, gneiss, mica-slate, clay-slate, porphyry or diorite.

Of the secondary formations bounding this basin, the oldest is the grès rouge Vosgien, which takes its place among the later sandstones of the coal formation. This rock, the most frequent colour of which is red, has been described as consisting of grains of quartz without any visible cement, and of passing, particularly at the tops of mountains, to the state of a pudding-stone. The rolled stones of which it is composed are white, reddish, black, and grey quartzites. Later secondary rocks consist of the grès bigarré, muschelcalc, keuper, lias, and oolitic strata.

Of the tertiary strata it may be generally remarked, that, in the *first* place, they include such as indicate the marine character of the basin of Mayence, during the commencement of the tertiary epoch, as, for instance, calcareous beds containing marine shells; —*secondly*, they comprise such as indicate the period when the basin of Mayence had a mixed character, or when it was about to become a fresh-water basin, whence the intermixture in the same calcareous strata of marine and fluviatile shells, or the alternations of marine limestones with such as are of a fresh water origin, with the well-known deposit of molasse, with lignites or bituminous strata;—and, *lastly*, they include strata of an unmixed fluviatile character, which have surmounted the whole.—These last named beds, which were the chief ones broken up by diluvial torrents, have been described under the name of loess.

After this short glance which I have taken at the geology of the Upper Rheinland, we may pursue our farther inquiries with more success.

It was remarked in page 193, that the diluvial current did not in the first instance display all its violence. Hence we are entitled to expect, that before the whole strength of the waters was displayed, transported matter would be allowed in various situations to subside, according to its bulk or specific gravity. Accordingly we find, that, in the upper valley of the Rhine, the lower beds, which are formed of whitish or greyish sand and argillaceous matter, are intermixed with a quantity of rolled stones, derived from rocks near at hand,—and that the rolled stones are identical with such as belong to the conglomerate rocks of the grès Vosgien. In some sites, according to various observers, the lower deposits consist of earthy matter, inclosing grains and nodules of ferruginous matter, in which manganese as well as pisiform iron ore are contained. These deposits are said to likewise contain land shells and animal remains.—(See *Journal de Geologie*, Vol. i. p. 33, &c.)

But in all, or most, of these examples of subsidence, the whole of the coarser or heavier materials are surmounted by a deposit of the lighter transported matter of loess, which will form the subject of an ensuing section.

This subsidence of transported matter, and its order of superposition, which has varied with its bulk or specific gravity, indicates, as I have hinted, that, in the first place, the diluvial current did not exert its whole force or violence. This reserve, however, was of short duration. An overwhelming power was soon exerted, the degree of which is only made known to us by the distance to which the loosened materials of rocks have been transported. While *schutt* and *gerolle* are said to have been transported from Switzerland, boulders have been propelled from Geislautern to Mayence, a distance of thirty leagues.

It has been remarked, that the constituent rolled stones of the grès Vosgien are easily destroyed; and hence the prevalence of these fragments, loosened from the Vosges and the Schwartzwald, along nearly the whole course of the Rhine.

In the basin of Neuwied, I certainly observed on the high grounds near Kehl fragments which might be referred to the grès Vosgien, consisting of conglomerate white, reddish, black, or grey quartzites; and in another spot not far distant, I picked up other conglomerate relics, consisting of smaller pebbles of this kind joined together by a ferruginous cement, which might likewise be considered as the transported fragments of these distant strata.

But additional testimony is afforded in the fact, that, upon the high ground below the volcanic peak of the Carmelenberg, I found resting upon an older deposit of quartzose gravel (described page 91,) fragments of a fresh water calcareous deposit exactly like that of Mayence, which contained Cyclostomæ, apparently the acutum and anatinum; and, as these fragments were little rounded at their edges, it is not improbable that they had been loosened by the debacle in its course.

It is remarkable, also, that, among the debris of the crater of Laach, I found a solitary fragment of tertiary limestone, evidently affected by fire, resembling that of Mayence. To this fragment I have before alluded. (See page 160.) I consider that the most rational supposition is that which would refer its transportation to the diluvium I am describing. At this period the crater of Laach is supposed to have been in activity, whence the marks of fire which the fragment exhibits.

These observations will suffice for the distant transportation of blocks and boulders, or gravel;—having described which,—I shall next speak of the strata of lighter matter, consisting of *loess*, the

breaking up and transportation of which form the most striking incident of the diluvium of the Rheinland.

SECTION V.—THE BREAKING UP AND DISPERSION OF THE UPPER FRESH WATER BASIN OF LOESS.

The loess which formed the highest beds of the tertiary deposits of the valley of the Upper Rhine I have already described, as consisting of fine pulverulent particles, connected together in a loose friable mass;—or as a loamy substance of a dirty yellowish grey colour, and in its fracture earthy, being a mixture of particles of argillaceous, calcareous, and quartzose matter, in which are interspersed minute scales of mica. The loess of Heidelberg has been said to contain earthy matter in the following proportions: Four parts of argillaceous matter combined with a fifth portion, consisting of the carbonate of lime, and a sixth of quartzose and micaceous sand.

In reference to the remark which was before made, that the first rush of diluvial waters displayed a violence, which, though great, was even less than the overwhelming effect which followed, we are entitled to expect, that, in the first instance, this less degree of force would allow the particles of the loess to subside in many convenient sites in an order of superposition varying with their specific gravity; which effect, unless under such mitigated circumstances, could scarcely have been induced. The process of deposition I shall now endeavour to trace.

The diluvial torrent, in breaking up the last fresh water deposit of loess, would transport this light earthy substance, while in a state of diffusion through its waters, along the whole, or the greatest part of the extent of its course. During this transportation, matter would, at every instant, be deposited. In proportion as the velocity of the torrent increased, large blocks would be removed, and would be the first deposited;—consequently we must conceive of them as occupying the lowest station. Above these would be deposited the heavier particles of sand, which would be still farther transported;—while above the heavier particles of sand the loess would be superimposed, which would be carried to the greatest distance, even to the embouchures of the Rhine. Lastly, upon the arrival of the diluvial waters at the sea, their celerity would begin to be lost, while their transportation would be confined to the lightest possible particles,—such as we may easily conceive would be carried to the greatest distance, even to the seas which now wash the shores of Holland.

The order of superposition which the transported matter has thus observed in the vallies of the Rhine may be observed in the vicinity of Strasburg. The lowest beds of some small hills, or knolls of transported loess which had been deposited, appear to

have included the heavier particles, consisting of sand, in which appear rolled pebbles distributed in the form of veins. In a higher bed, the sand which has thus subsided is varied by the presence of removed masses of loess, as well as by land and fluviatile shells, and even by the bones of the mammalia which it appears to have entangled in its course. But the uppermost bed is distinguished by the usual character of loess, which here displays itself of a yellow colour, and of a very friable consistence, in which are entangled shells and bones of animals. It is also perfectly unstratified.—(For various accounts of these subsidences, see M. Rozet's interesting dissertation given in the *Journal de Geologie*, Vol. i. p. 25 to 50.)

Such is the general order of subsidence which the loess in its breaking up, in its removal, and in its subsequent deposition, appears to have observed. Other circumstances connected with its transportation may now be noticed.

M. Von Leonhard has pointed out that deposits of loess would particularly occur in places where the current of the transporting waters would be less powerful, as behind the projections of hills, particularly in the vicinity of sites, where the full current of the stream would meet with resistance.—They would also be found in other places, as where two currents fraught with the light materials which they were transporting had become opposed to each other.

It has been likewise supposed that the loess would diminish in thickness according to the horizontality of the plain through which it has been transported, and that it would be the greatest near the sides of mountains.

Owing to these, as well as other circumstances, the thickness of the deposit must admit of considerable variations. With the dimension which that of the Upper Rheinland displays I am unacquainted;—at the Kirchberg, near Andernach, where, against the flank of this hill, the loess has abutted, all the thickness of the deposit which we are now enabled to trace amounts to about 66 feet;—but there is no doubt, as will be shewn hereafter, that it must have been originally much more considerable.

Regarding the different heights at which the loess appears in different places of the Upper and Lower Rheinland, there has been a great diversity of statements. One author affirms, that in the plains of Alsace and Lorraine, as well as of Baden, the height of the loess is 100 metres above the level of the sea. Another author estimates its greatest height at 200 or even 284 metres. In the basin of Neuwied, owing to causes remaining to be explained, I am inclined to think that the elevation which the loess has attained exceeds that of most places.

But precise information on some of these points of inquiry cannot be reasonably expected, and more particularly on account of

the loose and friable nature of the loess, which must have soon yielded after its deposit to causes of disintegration and transportation. At the present day, nothing more than comparatively slight patches of it are found, chiefly lining the flanks of such hills as have been more directly opposed to the force of the diluvial current. The localities in which the slight remains now appear, of what was once an immense transported mass, it becomes interesting to know;—I shall therefore present a list of the same, as far as can be gathered from the numerous authors who have treated of the Rheinland in general.

In the extended valley of the Rhine, if we trace the remains of broken up and dispersed beds of loess in the direction of their transportation, namely, from south to north, we shall find removed hillocks, or smaller traces of them, in the great plain between the Vosges and the Schwartzwald;—on the declivity of the hills from Wiesloch to Brucksal, and in the vicinity of Freiburg in the Breisgau;—over the plains of Alsace and Lorraine, as well as of Baden;—from Strasburg to Carlsruhe, where the loess attains some thickness;—in the vicinity of Heidelberg, and along the Bergstrasse, as at the Haarlass and near Neckargemünd, at Durlach, Handschuhsheim, Dossenheim, Leutershausen, Sassenheim, and near Weinheim;—near Alzey;—between Dienheim and Guntersblum;—at the Galzenberg and Schlossberg near Oppenheim;—at the Dreiserberg, and at Sahlbach, near Mayence;—in the Rheingau, a little above the level of the Rhine;—in the vicinity of Nassau, where it is visible in the defiles which lead to Homberg, Winnen, and Weinahr;—in the Lahn, and along the valley of the Rhine;—at the Vahnerkopf, the Carmelenberg, and near Saftig;—at Bendorf, at Sayn, and the Saynbach, at Neuwied, at Heddersdorf, and at Oberbieber;—at Monrepos, and at the Mahlsburg, where it is said to attain the height of nearly 600 feet above the level of the Rhine at Coblentz;—at Friedrichstein, Feldkirch, Fahr, and Genersdorf;—in the road from the Kirchberg, near Andernach, to Eich, the Nassberg, Wassenach, Tonistein, Burg Bruhl, and Nieder Zissen;—at Namedy and Fornich, where its accumulation in the Gorge of Andernach dammed up the basin of Neuwied;—at the Bausenberg, Gonnersdorf, and Ober Breissig;—at the Ahr;—and lastly, in the vicinity of the Siebengebirge, from which site we trace it no farther north, as the remains of it were no doubt dispersed and lost in the ancient ocean which once flowed near to Dusseldorf.

This account of the breaking up and dispersion of the loess I shall conclude by a notice of the relations of superposition which it exhibits in the basin of Neuwied to older rocks and strata, or even to coexisting deposits.

While in the upper valley of the Rhine the loess appears superimposed upon primary rocks, or upon the grès Vosgien, or upon secondary limestone, or upon tertiary limestone, (where, in the vicinity of Oppenheim, it is said to cover over a mass with a firm adhesive coating, to the thickness of half a foot,) or upon the gerolle, resulting from various pre-existing rocks, and particularly from the conglomerate strata of the grès Vosgien,—we find that in the basin of Neuwied it covers in various places primary rocks of clay-slate ;—secondary strata being here absent.

In a very few localities traces of the loess of the basin of Neuwied may be observed resting upon plastic clay and sand.

The relation of the loess to older volcanic products is best observed near the trass valley of the Bruhl. This appearance escaped my own observation, but it is said to occur near Wassenach, where a mass of loess about 10 to 20 feet thick rests upon tuffstein, as well as at Tonistein, where another mass under similar circumstances is observed from about six to twenty-one feet thick.

The relation of the loess to the older gerolle is seen in many places. Loess has been observed to lie on the gerolle at Sayn, Bendorf, Neuwied, and near Andernach. In descending the rather high ridge which intervenes between the Rhine near Andernach, and the trass valley of the Bruhl, we find upon a declivity towards Kehl, a deposit of loose earth and gravel, consisting of fragments of clay-slate to the depth of sixteen feet, while, over that, is a bed one to five feet thick of loess.—(The whole is surmounted by a bed of pumice of postdiluvian date one foot thick.)

The relations of the loess to co-existing deposits requires more attention.

In taking the incipient mitigated violence of the diluvial torrent into consideration, the circumstances under which the loess is found inform us, that, in its earliest removal, its transportation or accumulation was not at first so sudden or in such excess, as to prevent it after it was diffused through the waters of this lake from being deposited in a stratified state. Thus, near the Kirchberg, as well as in some other places, the lower beds of the loess show an approach to a stratified form. Nor are we sanctioned in the opinion, that the deposit was in the first instance a continuous one; its remissions, or perhaps intermissions, though probably short ones, being indicated by its alternation with other deposits. These alternations are not unfrequently seen during our investigations of the relation of the loess to co-existing depositions. —It must, however, be carefully kept in view that the great mass of the loess is unstratified.

The substances of more recent date dispersed over the surface

of the basin of Neuwied when the breaking up and dispersion of the loess had commenced, were the black sand as well as the more recent gravel which had been washed into the lake of Neuwied; the later volcanic ejections from volcanos; and the white pumice of the Humrichs. The relations of the loess to these substances I shall now consider in their order.

Alternations of the loess with the black sand of the lake of Neuwied are observable in various places, as in the low deepenings between Heddesdorf and Oberbeiber, and between Fredrichstein, Fahr, Gonnersdorf, and Feldkirch. The loess does not here attain a greater thickness than a few inches. Similar alternations are also observable between Bendorf, Bassenheim, and Octendung, where, likewise, occasional alternations of the loess with newer gerolle or gravel may be detected.

It is not, however, easy in these particular instances to distinguish whether the black sand, thus alternated with the loess, was derived from volcanos, such, for instance, as the crater of Laach, or the Humrichs, which might have been in activity during the time of the diluvium, or from black sand previously deposited, and washed among the loess, so as to form alternating layers.

Near Andernach the relation of the loess to later volcanic ejections, probably from the crater of Laach, is exposed.

The later ejections from the crater of Laach consist, as I have stated, of eruptions of trachytic cinders and ashes, which appear to have been going on so late as the close of the tertiary epoch, and even perhaps during the diluvial process, when the breaking up and dispersion of the loess took place. This is shown by the strata inferior to the loess, beneath the Kirchberg, which in a descending series appear as follows:—

(*a.*) A thick bed, or mass, of unstratified loess.

(*b.*) A bed 6 to 9 feet thick of a substance consisting of loess mixed with much dark coloured matter, resulting, apparently, from the lighter pulverulent ashes given out by the crater of Laach. It has been named a tufaceous conglomerate.

(*c.*) A bed of loess (like *a*) about 3 feet thick.

(*d.*) Bed of fine sand dipping 20° N. N. W. and containing fresh water shells; but whether these animals have been in recent times washed into the sand, I was not then able to determine.

Again, on the road leading from Andernach to Frauenkirch, I observed another section. It is given in a descending series:—

(a.) An upper bed 21 feet thick, consisting chiefly of pumice

which was deposited in a postdiluvian period. This will be described in a future chapter.

(b.) A fine mass of unstratified loess 45 to 48 feet thick.

(c.) A coarser mass of loess 18 feet thick.

(d.) An eruption of fine dark cinders mixed with minute fragments of clay-slate, alternated with a layer of volcanic ashes and loess, so intimately mixed as to appear in the form of a black mud;—amounting altogether to a thickness of three feet or more.

(e.) Another bed of a dark muddy consistence;—the depth unknown.

Lastly, the relation of the loess to the white pumice ejected by the Humrichs may be considered.

At Heddesdorf and at the Saynbach it is said that pumice-stone beds are covered by masses of loess from the depth of 5 to 20 feet and upwards. I have not seen this appearance, and must therefore question if it has not been in part produced by recent alluvial causes, which have transported the loess to this situation.

Less equivocal appearances may be detected in other places. From Heddesdorf to Oberbeiber and between Friedrichstein, Fahr, Genersdorf, and Feldkirch, layers of loess, only a few inches in thickness, are not only observed to alternate with white pumice, but even with black sand. Similar appearances again present themselves at Bendorf, Bassenheim, Octendung, and Obermennig.

Whether black sand from the Humrichs was ejected at the time of the diluvium, or whether, in the particular localities last stated, its alternation with the loess may not be rather considered as the result of an older deposit, subsequently conveyed thither by floods, I have considered as rather doubtful. That the crater of Laach gave out cinders and ashes during the time of the diluvium must, I think, be strongly suspected; and that white pumice was ejected during this interval there can be no doubt, as proofs are afforded of the Humrichs having been in activity both before and after the diluvian period.

## Section VI.—The Mineral substances entangled by the Loess during the course of their transportation.

The mineral substances entangled in such removed or transported debris or beds as are to be found subjacent to the loess, have been already described. In this section, therefore, I shall confine myself to the minerals entangled in the loess itself.

In the upper Rheinland such entangled substances are recorded, as thin folia of siliceous sandstone, or psammite; concretions composed of marl and sand; stalactitic matter and other products, the specific gravity or bulk of which has not been so considerable as to prevent their transportation in an entangled state.

In the basin of Neuwied we find that occasionally small pebbles of quartz have been entangled in the loess, as well as concretions of a marly nature, and, though rarely, fragments of basaltic scoriæ. But the entangled substances of the greatest geological importance are those of the white pumice which had been yielded by the Humrichs, by which, as well as other circumstances, we arrive at a comparative knowledge of the period when the volcanos which yielded them first became in activity. At the same time, pumice is but sparingly discovered entangled in the loess, for which, as well as for other reasons, we infer, that the great eruptions of pumice with which the Mayenfeld is covered over are referable to a postdiluvian epoch.

## Section VII.—The overwhelming of Forests, and the great destruction which befel many animals during the progress of the diluvial current.

The great overwhelming of the forests situated in the vallies of the Upper and Lower Rhine, as well as the destruction which must have befallen many animals during the progress of the diluvial current,—are incidents so naturally to be expected that they need no comment.

We learn from the carbonaceous matter diffused through the loess of the Upper Rheinland, that many turf coverings were swept away, and, from the fragments of dicotyledonous plants observable, that a similar fate befel several forests.

Many of the remains of the larger mammalia which were overwhelmed in the diluvial catastrophe appear in beds subjacent to the loess, where they had subsided. Such bones as have been found entangled in the loess are said by M. Von Leonhard to have been in general much decomposed;—which creates a suspicion that this might have been their state before they became entangled in the loess, and that the diminished specific gravity of an osseous substance, characterized by a cancellated and void structure, had influenced their entangled state.

The bones of the larger animals found in the loess are referred to the Elephas primigenius and the horse. Teeth of the former are said to have been found not far from Weinheim in the Bergstrasse. M. Boué conceived at one time that some human remains, which he had discovered long ago in the loess of Buden, were imbedded under circumstances which pointed to their antediluvian origin. But the site demanded a re-examination to which no geologist was capable of doing more justice than M. Boué himself. He now thinks that by much later causes, as by ordinary river floods, with which we are at present familiar, the bones might have been worked into the soft substance of the loess.

The land and fluviatile shells entangled in the loess are what

we might reasonably expect, from their extreme lightness, to discover. As many of them have by recent alluvial causes been evidently washed through fissures and apertures into the substance of this loose and friable mass, where they appear imbedded in it at some little distance from its surface, it is not at all times easy to say which of them might have had an antediluvian origin, or which of them might have had a postdiluvian date. The shells are described as keeping in part their natural colour, but as being in general very white and tender. This is no satisfactory indication, as very recent adventitious causes are capable of producing this appearance. M. Von Leonhard admits that such shells as belong peculiarly to the loess have been hitherto little examined, as an example of which he cites some species of Helix and Lymneus.

The shells which have been enumerated as occurring in the loess, are the Physa, Paludina, Clausilia, Pupa, Helix, and Lymneus.

Of the Helix the following species have been enumerated: Helix pomatia, nemoralis, striata, pulchella, and cristallina. In the Upper Rheinland a larger species of helix is said to occur near Oppenheim at the Galzenberge, and a smaller one near Weinheim, (not far from Alzey,) at the Haarless, and near the Neckargemünd.

Of the Lymneus two species are stated to occur in the loess; the pereger and ovatus.

The sites where shells are collected in the loess of the Basin of Neuwied have been enumerated by writers as follows: Bendorf, Neuwied, Andernach, Eich, Zissen, Burg Brühl, Tonistein, and Gonnersdorf near the Bausenberg.—I have myself only examined the shells which I found in the vicinity of Andernach.

### Section VIII.—The choking up of the Gorge of Andernach by the immense volumes of loess which were transported into it, and the restoration of the high level of the Basin of Neuwied which followed.

During the most violent course of the diluvial current an effect took place which might be readily anticipated. When we consider that the whole of the lacustrine deposit of the great fresh water basin of Mayence was broken up, and that this broken up and chaotic mass was proceeding with inconceivable rapidity down the channel of the Rhine, we may readily conceive of the effect which such an obstacle as the narrowness of the Gorge of Andernach would oppose to the force of the debacle.

The loess in its propulsion through the swollen waters of the lake of Neuwied would first have its progress impeded by the ridge of hills extending from Eich to the Kirchberg, where, ac-

cordingly, we find the remains of a deep deposit, and by the opposite high declivities of the Rhine, namely, at Monrepos, and at the Mahlsberg, where, according to an estimation which has been made, the loess has attained an elevation of near 600 feet above the level of the Rhine at Coblentz. The rest of the broken up beds of loess, with which the waters were fraught, would be propelled in the direction of the narrow gorge of Andernach. But, in the attempt to pass these straits, so great must have been the bulk of the accumulated masses which would breadthen themselves across the barrier, increased by the renewal of still newer transportations from the south, continually going on, that the narrow gorge appears to have been at length completely choked up, even to its utmost height. The consequence has been, that the waters of the lake of Neuwied were again elevated to a height of seven hundred feet or more above the level of the Rhine at Coblentz.

The evidences of this choking up of the gorge of Andernach, which are very striking, may be seen above Namedy and Fornich, at present situated a little to the north of Andernach. In ascending these heights from the Rhine, we find resting upon an old bed of sand and gravel the remains of a mass of loess, which now coats the steep declivity of the hill which constituted the wall of the ancient gorge. On the opposite shore, also, near Leudesdorf, remains of the loess may be traced, though the appearance is not near so striking as in the heights above Namedy and Fornich.

After this damming up of the waters of the lake of Neuwied, the basin again presented the same appearance which it had assumed at the commencement of the tertiary epoch, with this exception only,—that the current of the Rhine, which had formerly derived its source from the comparatively insignificant heights of the Hundsruck or the Taunus, became fraught with the waters from the far distant Alps.

## CHAPTER XXVI.

### THE CONVULSIONS WHICH TOOK PLACE IN THE VICINITY OF NIEDERMENNIG DURING THE DILUVIAN CATASTROPHE, WITH THE ERUPTION OF PUMICE FROM A FISSURE OF THE LAVA NEAR TO THE PRESENT SITE OF THUR.

It was stated, (page 187,) that the Basin of Neuwied must in some degree have partaken of the convulsion by which the high European Alps sustained a considerable elevation;—and that on the right bank of the Rhine, near Gladbach, strata of black sand

might be found much inclined and dipping to the east or north-east, towards the hill above the village of Romersdorf. M. Steininger conceives that by some violent and extraordinary earthquake the high situation of the loess above the hill of the Nassburg may be explained. But this is a doubtful inference, as the loess has been observed in other places to assume fully as high a position. He is more fortunate in his remarks on the convulsion which is indicated by the fissure of disruption observable in the lava of Mennig.

I am inclined to refer to the period marked by the diluvial catastrophe, a deep fissure through which a small stream now flows, which has been formed in the solid millstone lava of Mennig. It may be traced in the ravine bounded by lava walls, which runs east from Obermennig for a considerable distance, in which ravine Niedermennig is situated.

M. De Wyck, in admitting that a great convulsion must have taken place in the vicinity of Niedermennig and Thur, has attempted an explanation of it, which is exceedingly perplexed, and which is scarcely warranted by actual appearances. He forms to himself the notion of some continuous basaltic lavas extending almost in the form of a crescent from Obermennig to Thur, which had their origin in a crater that lay between Thur and certain hills now concealed by an alluvial covering, named the Etterberg, the Rabenberg, and the Kammeshall;—which crater, by the operation of an earthquake, has totally disappeared in a deep abyss, along with the greater part of the lava flow. He lastly supposes that, in connection with later alluvial deposits, a valley has been formed in which the stream of the Mennig now flows.—*(See page 51 of M. De Wyck's Memoir.)*

It is very difficult to subscribe to this hypothesis. Although there are evident marks of a considerable convulsion which must have taken place in the vicinity of Thur and Mennig, the true extent and character of which has been obscured by the circumstances under which it took place, namely, under diluvial waters, I am inclined to think that the very simple view which M. Steininger has taken of the phenomena is much to be preferred, and that most of the appearances actually presented are referable to a convulsion which caused a deep fissure of disruption in the lava of Mennig.

But still other effects have resulted, which appear to have consisted in the escape of pumice from the fractures induced in the lava.

I have already remarked, that, during the actual period of the diluvium, as well as immediately subsequent to this event, we must conceive of eruptions of white pumice as still going on.

These have been described (page 172) as having been derived from felspathose rocks;—and as showing more the igneous modifications of greystone or trachyte than of basalt.

The pumice thus ejected has been considered as exhibiting the following characters:—as being of a pure white, greyish white, or yellowish white colour with a silky lustre;—as being remarkably fine and porous, with a fibrous structure;—as being so light as to readily float upon water so long as its pores are dry, but as sinking so soon as its pores are entirely penetrated;—and as containing such minerals as Hauyne and glassy felspar.

Regarding the size of the fragments of pumice ejected, it was remarked that they varied from the dimensions of three or four inches to that of small grains or even of pulverulent particles; and that under this last form the pumice might be described under the name of pumice-stone dust.

Lastly, it was observed that the exact circumstances under which the pumice was ejected were rather obscure; that, as far as could be collected from the appearances presented, the ejection of fragments of pumice was a process effected less by one grand explosion, than by numerous reiterated ones, prolonged during a considerable interval of time;—that the pumice had in some instances escaped by comparatively small fissures, and, in others, through craters previously formed.

It was during the time when the lava of Mennig became fractured, and manifested various yawning fissures, that an eruption of pumice evidently appears to have taken place in that part of it, which had for its site the present rising ground situated between Niedermennig and Thur, where at present stands an ancient chapel. By this eruption the lava was still more shattered, as is shown by the disjointed blocks which appear strewed about the hill in the most remarkable confusion, as if they had been torn up by the ancient Titans of our classical romances.

The site of this event must be considered as greatly elevated, so that the surface of the hill of Thur could not have been very deep under diluvial waters. Hence, when a great discharge took place through the fissure thus induced of showers of white pumice, they must have been projected above the surface of the lake. But, in descending among diluvial waters, many of the fragments appear to have insinuated themselves among the chinks and cavities intervening between the torn up blocks of lava, in which they have been assisted by the earthy matter derived from sublacustrine and broken up beds of sand, clay, and tufa, so as to impart to the effect which has been produced a picture of the most singular distraction.

Other fragments of pumice projected appear to have descended on the high land to the west and south-west of Thur, where they

may be traced near Mayen, Ettringen, and the Hoch Simmer, and, even in this last direction, as far as the westerly bank of the Nette. A layer of white pumice at the foot of the Hochstein I was long in doubt whether to consider as having proceeded from this much more ancient volcano or from Thur, but from the difference of its character I have been induced to regard it as an older eruption of pumice. (*See page* 111.)

## CHAPTER XXVII.

### THE MUD ERUPTION WHICH TOOK PLACE IN THE VICINITY OF THE HUMRICHS, AT THE TIME WHEN THE WATERS OF THE BASIN OF NEUWIED WERE MAINTAINING THEIR RENEWED HIGH LEVEL.

THE continuance of eruptions of pumice was probably promoted by the causes which gave rise to the diluvial catastrophe. The Humrichs, the highest of which is 725 Rhenish feet above the level of the Rhine at Coblentz, had been covered with water, during which flooded state it is evident that no eruptions could take place except such as were sublacustrine. The craters which they possessed would become filled with water, and assume the state of crater-lakes, giving rise to such results as the volcanos of Rieden, Fusel, or the Lummerfeld have presented. This is indicated by the immense accumulation of tuffstein at the foot of the Humrichs, the origin of which has much puzzled the geologists who have examined this district.

M. Schulze conceives, that, from the volcanic hill of the Krufter Ofen, situated to the south-east of the crater of Laach, the tuffstein might have been ejected. He has also named another possible source of it, which is from the crater of the Nikenicher Weinberg, or, as it is variously named, the Nickenicher Sattel. M. Steininger, again, supposes that it was from the crateral opening of the Krufter Humrich that the tuffstein was ejected.

With regard to my own opinion upon these supposed sources of the tuffstein, I would altogether reject the claims of the Krufter Ofen, which shews no appearance whatever of having given out the white pumice which is the chief and almost sole ingredient of the tuffstein.

The Nickenicher Sattel has far more claims to our suspicion, as it must have been filled with water during the diluvial catastrophe, and if it had then been in activity, its crater would certainly have been filled with boiling mud. The immense quantity

of pumice and pumice-stone dust, which might have ascended through different fissures into the crater, would be intercepted by the waters which filled it, and, after the manner which I have often described, would be filled with boiling mud.

That the Nickenicher Sattel contributed to this accumulation of tuffstein is by no means improbable, but its chief source may, I think, be referred to the Krufter Humrich.

The Krufter Humrich has been described as shewing some little evidence of having had a large crater-shaped opening on the summit, which, from some unknown cause, has been defaced. (See page 171.) In the Eighth Plate of this work, (p. 168,) its appearance, in the second view given, is certainly much like that of a broken down crater. Accordingly, on the supposition that when entire it was submerged, and that during this time it was filled with boiling mud, it would appear, that the walls to the south-west of the crater became subsequently rent, and that an immense mass of tufaceous mud, or moya, flowed from its side, and found a lodgement in the ravine which sweeps the base of the Humrichs. M. Steininger, who first suggested a view similar to this, states, that he traced the run of the liquid mud from the actual basis of the mountain. Along this ravine the present villages are situated of Kruft, Kretz, and Plaidt.

Whether the Plaidter Humrich had contributed in any degree to the tuffstein is very doubtful. M. De Wyck affirms, that he traced a perfect crater in it, which he estimates at 585 paces in circumference, and that it was subsequently filled up and rendered obscure by floods from the west.

But quitting this field of conjecture, there can be little or no doubt whatever, that the Krufter Humrich was the principal source of the tuffstein, and that no other volcanic crater is so likely to have added to the deposit as that of the Nickenicher Sattel.

When this eruption, or overflow of moya, took place, the ravine in which it became lodged was submerged. But even under these circumstances, comparatively little of it would be swept away. Its refrigeration amidst the cool waters of the lake would quickly take place, and its induration would follow.

The base of the tuffstein thus accumulated, is of a yellowish-white, greyish-yellow, or even reddish-grey colour. It is of an earthy consistence, appearing to be composed of pumice-stone dust, in which fragments of white pumice of different dimensions, some amounting to several inches, are interspersed. Minute portions of clay-slate, or sand; as well as basaltic scoriæ, are occasionally found in the tuffstein.

This substance admits of several varieties, chiefly consisting in its degree of fineness or firmness, by which it is recommended to as many different economical purposes. These have been described,

with even more minuteness than is perhaps necessary, by M. Faujas St Fond, from whose account the following abstract must suffice :—

One variety, which occupies, as I conceive, the lowest situation in the bed, has a base formed of pumice-stone dust, in which fragments of pumice are interspersed. It is represented as very hard, and as having a *dry grain*, on account of which it is said to form, when ground, the best trass. In this tuffstein there seems to be contained much adventitious matter, consisting of clay-slate, sand, scoriated basalt, &c.

A second variety, which is of a grey, or reddish-grey colour, has also a dry grain, but is more friable than the last variety described. It is likewise used for grinding into trass.

A third variety is said to have a very fine grain, or, in more explicit terms, it is composed of very fine particles of pumice-stone dust. Its texture is also more compact and equal than the last described, and it contains less adventitious matter. As it is easily worked with a chisel, it is raised in considerable blocks, and employed for architectural purposes. Many of the images of saints, which are so densely interspersed throughout this district, are formed of this stone.

A fourth variety, of a yellowish-white colour, only differs from the last in its paste or base being not so fine or compact. It is said to be too tender, and of too earthy a consistence to form good trass.

A fifth variety, named *Tauchstein*, cited by M. St Fond, generally forms an upper bed, and is more entitled to be considered hereafter. It appears to have been composed of materials which were not ejected from volcanos in the character of a moya, but of pumice-stone dust and pumice. These, in falling into the water, were consolidated in the form of submerged and conglomerate beds of pumice-stone.

M. Faujas St Fond has also remarked, that, in the tuffstein of Plaidt, carbonized remains of plants or trees have been found, resembling, as far as I can glean from his description, such as are imbedded in the tuffstein of the trass valley of the Bruhl. Of this circumstance I was not myself apprized when I visited the quarries of Plaidt.

The tuffstein, as we might expect, is entirely devoid of stratification. In the quarry of Kretz, a sort of divisionary structure has been observed in it, by which it has presented the forms *(via humida)* of large prisms. This divisionary structure is said to much assist the operations of quarrying.—*(See the Museum d'Histoire Naturelle*, Vol. i. p. 15 to 26.*)*

## CHAPTER XXVIII.

### THE DIMINUTION OF LEVEL, WHICH, AT THE COMMENCEMENT OF THE PRESENT GEOLOGICAL EPOCH, THE FLOODED WATERS OF THE BASIN OF NEUWIED BEGAN TO SUSTAIN.

It was shewn, in the 25th chapter of this memoir, that the strata of loess, broken up and transported by the diluvial catastrophe, had blocked up the waters of the basin of Neuwied, and that they had again stood at the height of seven hundred feet or more above the level of the Rhine at Coblentz.

During this catastrophe it would be most unreasonable to expect, that, throughout the district of the Rheinland, a general destruction had ensued of vegetable and animal tribes. The plants of elevations above the level of the swollen waters, as well as the animals which had sought for refuge in them, would, of course, remain unaffected. It is not, however, improbable, that new vegetable, as well as animal tribes, were from this time called into existence, in correspondence with the new state of soil which was succeeding to the gradual subsidence of the swollen waters.

This subsidence soon commenced. The loose friable substance of which the loess was composed, which had choked up the gorge of Andernach, began to yield to the regular flow of waters issuing from remote Alpine heights, and was in the process of being swept away into the lower basin of Cologne, and thence finally transported into the German Ocean.

For rather a long period, however, the waters may be supposed to have sojourned on the soil of the country;—a fact which is indicated in the Upper Rheinland by the great alluvial bed of rolled pebbles which is to be found upon the plain situated between the Vosges and the Schwartzwald, which afterwards became covered with a turfy mud containing vegetables and animals, the same as at the present day.—(*Journal de Geologie*, Vol. i. p. 36.) In the alluvial soil of the basin of Neuwied, also, we find indications of the same abiding of the waters. A higher bed, for instance, which covers the lava of Mennig, has attained a thickness of nearly forty feet, in which we observe an aggregated deposit,—in part only diluvial,—swept from adjacent heights, consisting of pumice, fragments of porous lava, and cinders. Again,—it is stated, that near the summit of the Krufter Humrich a deposit of a coarse description of gravel has been discovered. But this appearance did not present itself to my own observation.

With the subsidence of the convulsions which had caused the elevation of the distant Alps, with the cessation of the diluvial

current, and the retreat of the flooded waters of the vallies of the Rhine, the present epoch commenced, which, in process of time, became recorded in the historical documents of the human race.

## CHAPTER XXIX.

### THE LATER EJECTIONS OF PUMICE WHICH ARE REFERABLE TO THE COMMENCEMENT OF THE PRESENT GEOLOGICAL EPOCH.

In the basin of Neuwied, the present geological epoch was ushered in by fresh eruptions. The Humrichs again heaved from the pressure beneath them of more recently elaborated gases, which, in their renewed ascent through fissures previously formed, were accompanied with showers of white pumice.

Whether, during the same period, the crater of Laach likewise gave out its own peculiar ejections of darker coloured trachytic scoriæ, I must consider as a question of much uncertainty;—the distinction not being very easy to be made, whether the trivial layers of darker coloured volcanic matter occasionally alternating with upper accumulated beds of pumice, are to be considered as older volcanic products washed thither by rains, or as the result of renewed, though very slight, eruptions from this ancient volcano. In proceeding, for instance, from Thur to the Laacher-see, I found white cinders, (probably given out by the eruptions of Thur,) frequently surmounted by darker volcanic matter, such as might be referred to the crater of Laach. Near Kretz, again, strata, indicating an intermixture of the volcanic products of the Humrichs and the crater of Laach, may be found covering beds of white pumice.

The Humrichs of Kruft, Kretz, Plaidt and Saftig, as well as the Nickenicher Sattel, were originally, as it has been observed, volcanos which gave out dark basalt slag, cinders, and volcanic sand. Their subsequent ejections of pumice, which may be considered as having taken place from old volcanic crevices, have so covered the whole surface of them, as, in some places, to almost conceal the surface of the slag hills, and to lead the hasty observer to suppose, that they were altogether eruptions of pumice.

There is every probability, as I have already shewn, that the earliest eruptions of pumice took place from the Humrichs of Kruft, Kretz, and Plaidt. The slag hill of Plaidt, which shews two heads, the one near Plaidt, and the other near Kretz, might have yielded some little of the substance, which, in floating down the Rhine, formed the lower beds of submerged conglomerate pumice which are worked near St Sebastian's, as well as the lower beds of

such as were deposited on the banks of the nearly drained lake of Neuwied. But, as the apertures, or previous fissures, whence the pumice must have made its escape, are so ambiguous, any opinion upon the exact identity of the deposits of this kind must be expressed with caution. It is perhaps more satisfactory for us to know, that all the Humrichs described, namely, those of Kruft, Kretz, Plaidt, Saftig and Nickenich, had in their turns given out pumice.

The later ejections of pumice which took place, that is, subsequently to the formation of the tuffstein, may, I think, be referred to the Humrichs of Saftig and Plaidt, and to the Nickenicher Sattel. At the same time, I would by no means exclude the possibility, that eruptions from the Humrichs of Kretz and Kruft had wholly subsided. It is not in every instance easy to make a distinction between these products of various volcanic hills, and the more so, since the pumice given out by them all appears uniform in its mineralogical character.

But there are again still other circumstances which render it extremely difficult to trace these ejections of pumice to their exact source. They do not appear to have shewn any distinct accumulation around the aperture or apertures whence they might have issued, but, from their extreme lightness, to have been carried by currents of air to greater or less distances. In fact, the only reason there is for concluding that the pumice was ejected from the Humrichs of Saftig, or of Plaidt, or from the Nickenicher Sattel, is, that pumiceous fragments of the largest magnitude are found in their immediate vicinity, and that a decrease of magnitude is perceptible in proportion to the distance to which the dispersed matter is traced.

The prevalent winds which have transported ejections of pumice to a greater or less distance from such points of eruption as we follow in a line from the Nickenicher Sattel to the Humrichs of Saftig, have evidently been from the south or south-west. At the same time, some exceptions to this more general result appear. Thus, for instance, the occasional occurrence of easterly or north easterly currents of air may be inferred from the circumstance, that white pumice has been sparingly dispersed as far as Kloster Laach, the Hochstein, the westerly bank of the Nette opposite the Hoch Simmer, Hausen, (near the quarries of Kottenheim,) and the vicinity of Polch, and Octendung. At the latter place, which is situated exactly below the Humrichs of Saftig, yet to the south of the groupe, the fragments of pumice, as we might naturally expect, grow larger, while the accumulation of them rapidly increases;—indicative, as I have before explained, that we are here approaching the actual line of pumiceous eruption.

In the tract thus described, where pumice-stone fragments have been dispersed by less prevalent winds, we are scarcely warranted in concluding that the whole had its origin in the various Humrichs extending from Saftig to Nickenich. Much, and perhaps the far greater part of the pumice strewed over the rocks and soil in this direction, is attributable to the eruption which was developed in the vicinity of Thur.—This was pointed out in a preceding chapter. (See page 207 and 208.)

After these observations on the exceptions which might have occurred to the more common direction observable in the dispersion of pumice by currents of air from the south or south-west, I shall now confine myself to such accumulations of it as we trace, agreeably to the presumed course of the prevalent winds, along the north or north-east of the given line of eruption, stretching from the Nickenicher Sattel to Saftig, or to localities more or less remotely situated from this line.

The accumulations thus distributed arrange themselves geographically, as follows: 1*st*, they occur on the south and west of the ancient lake of Neuwied; 2*dly*, they occur in the form of strata which have been submerged and consolidated beneath the deep waters of the lake of Neuwied; and, 3*dly*, they occur on the northerly margin of the ancient lake of Neuwied. These several distributions suggest corresponding divisions of the present chapter.

## Section I.—The accumulations of Pumice which appear on the southerly and westerly margin of the ancient Lake of Neuwied.

The accumulations of pumice which appear to the south and west of the ancient lake of Neuwied, admit of a further division with regard to their localities. They appear, 1*st*, at the foot of the Humrichs of Saftig and Plaidt; 2*dly*, at a greater distance from these volcanic points of origin, namely, from the stream of the Nette, near its confluence with the Rhine, as far east as the confluence of the Moselle and the Rhine near Coblentz; 3*dly*, near the Humrichs of Kretz; 4*thly*, at the foot of the Nickenicher Sattel,—which crater appears to have given out most of the pumice which has been transported in the direction of Andernach; 5*thly*, to the west of the crater of Nickenich; 6*thly*, as far as Eich, Kehl, and the neighbourhood of Tonistein and Fornich; 7*thly*, over the surface of the hill east of Eich; and, 8*thly*, near Andernach.

These several sites, to which much pumice has been transported, will be described in the order given.

### (1.) *The accumulations of Pumice at the foot of the Humrichs of Saftig and Plaidt.*

The greatest accumulations of pumice are to be found at the

foot of the Humrichs of Saftig and Plaidt, whence may naturally be suspected that the chief source of the pumice is referable to these volcanic hills. But, as I have remarked, owing to the ejected fragments of pumice, by reason of their extreme levity, having been transported to a considerable distance, a complete distribution of pumice around a crater or vent is not to be expected. It is from the size of the fragments here found, that we more particularly infer that the Humrichs of Saftig, and perhaps also of Plaidt, gave out pumice. In this locality, while smaller pumiceous fragments have been transported to a greater distance, larger portions only of this substance have descended near their respective points of eruption. M. Faujas St Fond was the first to remark that he here found, resting upon the great bed of tuffstein already described, a stratum five feet thick, consisting of angular fragments of white pumice, the smallest of which were of the size of an almond, or of a nut, while the larger ones had attained the size of a large egg. M. Steininger again has observed, that the largest of these fragments are of the dimensions of ten to twelve inches. Intermixed with this accumulation, fragments of clay-slate are observable.

I am inclined to think that in the site where these larger fragments were first accumulated, the floods were still high, and that so soon as their pores had become saturated with water, by which they had acquired a greater specific gravity, they had become submerged. This inference meets with some support by a bed two to three feet thick (first described by M. Faujas St Fond,) appearing above the white pumice, which is composed of smaller pumiceous portions, apparently washed from some distance, as well as of fragments of basaltic scoriæ and of clay-slate. A sort of conglomerate rock has been thus formed, which, however, is little coherent. It has been employed for the structure of walls. The upper layer of this deposit, which has been subsequently mixed with vegetable matter, constitutes the arable soil of this vicinity.

This lacustrine state of the vicinity of the Humrichs becomes still more apparent in our examination of the strata near the village of Saftig. On the east of the Humrichs of Saftig, where accumulations of pumice attain the greatest thickness, the subjacent beds show dark layers of tufa formed by volcanic sand and ashes, washed from adjacent slag hills. In other spots the lower strata consist of lake mud mixed with black volcanic sand, and portions of slag and clay-slate. As we ascend, these dark-coloured deposits become interstratified with white pumice, indicating that the pumice-stones had fallen in muddy waters, and that, along with their subsidence, an alternation had taken place. In other places darker volcanic matter is mixed with white pumiceous matter, proving that each was equally diffused through the waters.

Above the whole are beds of white pumice, from 6 to 9 feet thick, interstratified with similar pumiceous matter in a minute state of disintegration. Also, in one or two sites, the pumice, in consequence of finer particles having operated as a cement to the larger ones, shews a tendency to a conglomerate structure; which effect had probably arisen from the water, long after the subsidence of the floods, having been lodged in cavities. It has, for instance, been pointed out, that the light fragments of pumice which had fallen into the lake of Neuwied, would only float so long as their pores were unsaturated with water;—it may be therefore now added, that the subsidence of each stratum of them must have been followed by that of the finer pulverulent particles of pumice which had been suspended by the waters; and that upon the process having been continued, a series of alternating beds had become the final result.

In these instances, the pumice had fallen upon the margin only of the lake of Neuwied, where the waters, owing to the drainage which was going on, had not long sojourned. If they had much longer remained, the pulverulent particles which had fallen into this part of the lake would have so insinuated themselves among the larger fragments of pumice, as to have formed more coherent strata. But the submerged strata thus deposited were soon left dry, and, as a consequence, there was occasionally produced a series of beds, alternating with finer seams of pumiceous matter.

(2.) *The accumulations of Pumice which appear at a greater distance from the Humrichs of Saftig and Plaidt, namely, from the stream of the Nette, near its confluence with the Rhine, as far east as the confluence of the Moselle and the Rhine, near Coblentz.*

In this direction, we trace accumulations of pumice along the whole of the southerly margin of the ancient lake of Neuwied, (the waters of which were then subsiding,) namely, from Weissenthurm to Kettig, Kaerlich, and Rubenach, as well as in a more easterly direction, namely, from Saftig to Bassenheim, and thence to Coblentz.

Near the high road from Andernach to Coblentz, where Engers, situated on the opposite side of the Rhine, has a bearing to the north, we find superimposed upon strata of river gravel and sand, which are alternated for a thickness of five or six yards, a bed of pumice and sand much intermixed, and, over the whole, a very thick layer of fragments of pumice, evincing marks of attrition. Near the bed of the river, fragments of pumice are very thickly deposited, even to a depth of six to nine feet, where they rest upon river gerolle. But, as we approach Coblentz, the accumulations of pumice begin to thin off, and, on the road to Mayen, we find the following section :—

(*a.*) Superficial vegetable soil; 2 feet thick.
(*b.*) Very fine gravel, formed by fragments of clay-slate and quartz, in which are small fragments of pumice; 1 foot.
(*c.*) Fine gravel; 9 inches.
(*d.*) Very fine gravel, in which fragments of pumice occur; 21 inches.
(*e.*) Deep red clay or marl, mixed with river gravel; depth unknown.

Such are the accumulations of fragments of pumice on the southerly margin of the ancient lake of Neuwied. By a more distant transportation of them in an easterly or north-easterly direction, they have descended upon the surface of the ancient lake of Neuwied, where, upon their pores becoming filled with water, they have sunk, and have thus given rise to a series of submerged strata, which will require to be described under a distinct head.

(3.) *Section of Pumiceous Strata near Kretz.*

Again,—in another section, on the east of the crater of Nickenich, near Kretz, there is a considerable deposit of pumice, alternated with pumice-stone dust, which has been hardened in the form of a white mud. This deposit was probably induced by the conjoint activity of the Humrichs of Plaidt and Nickenich. Its beds, in a descending order, are as follow:

(*a.*) Recent alluvial matter; consisting of pumice, mixed with small fragments of clay-slate and vegetable soil, which had been washed into this situation after the waters had subsided. It is remarkable, that in this upper bed there is an intermixture of darker-coloured matter, comprising volcanic ashes and particles of clay-slate. Whether this appearance is attributable to a later eruption from the Laacher-see, or to alluvial causes transporting to this site the far older products of some volcano, is a subject of difficult inquiry.
(*b.*) Three or four very thin alternations of vegetable soil and pumice; 3 feet thick.
(*c.*) Bed, consisting of fragments of pumice 7 to 8 feet thick.
(*d.*) Very thin alternations of pumice and pumice-stone dust; the latter consolidated in some little degree in the form of a white mud; the whole not thicker than 2 or 3 inches.
(*e.*) Fragments of pumice in a bed about 9 inches thick.
(*f.*) Very thin alternations of pumice and pumice-stone dust, like the bed marked *d*; thickness about 3 or 4 inches.
(*g.*) Fragments of pumice about 18 inches thick.
(*h.*) Thin alternations of pumice and pumice-stone dust like beds *d* and *f*; about 9 inches thick.

(*i.*) Fragments of pumice; 9 inches thick.
(*k.*) Thick deposit of tuffstein, which is quarried for the purpose of grinding into trass. This is the lowest observable bed.

(4.) *The accumulation of Pumice at the foot of the Nickenicher Sattel;—which Crater appears to have given out most of the Pumice which has been transported in the direction of Andernach.*

At the foot of the Nickenicher Sattel, there is exposed, in a section near the road to Kruft, a lower bed, six feet in thickness, of dark-coloured slag, cinders, &c. the result, most probably, of an *antediluvian* eruption from the crater, while, above it, is a bed, three feet thick, composed of white cinders, with which layers of white pumiceous dust are alternated, indicating that this interstratification might have taken place under the water during its rapid subsidence. Superimposed on the whole, is a bed, six feet thick, of pumice, mixed up with cinders, and comparatively recent alluvial matter.

(5.) *The Conglomerate Strata west of the Crater of Nickenich.*

While the preceding sections show that some portion of the ejected pumice had in its descent been lodged in localities, where, at the time, the waters stood high, but where they were in a quick process of subsidence, another site exhibits rather different circumstances of deposition.

On the west of the crater of Nickenich, the water, owing to a deep fissure which afforded for it a lodgement, appears to have remained much longer. Rather large fragments, reduced by attrition to a rounded form, and of the dimensions of 1 to 3 inches, appear to have been here accumulated, which are commonly supposed to have been cemented by a calcareous infiltration. But it is evident, that the consolidation has been aided by the addition of pumice-stone dust. A coarse conglomerate has been thus formed, which is very porous.

The foregoing remarks include what I have to say upon such accumulations of pumice as are to be found in sites nearest to their several points of eruption, namely, in a line extending from east to north-west, namely, from the Humrichs of Saftig, Plaidt, and Kretz, to the Nickenicher Sattel. I shall therefore next describe such pumiceous beds, or layers, as appear to have been transported to a greater distance from this line of proximity.

(6.) *Dispersion of Pumice as far as Eich, Kehl, and the neighbourhood of Tonistein and Fornich.*

A very considerable accumulation of pumice appears to the

north and north by west of the Nickenicher Sattel, which may be traced as far as Kehl, and even to the vicinity of the trass valley of the Bruhl. On the supposition that the crater of Nickenich gave origin to it, as is indicated by the great accumulation of pumice around it, which has been already described, the first remote dispersion which I shall notice is that which is revealed to us in the Niesbusch quarry near Eich, the subjacent rocks and deposits of which have been already described. (*See pages* 127 *and* 182.) A section of the beds which form this accumulation I shall now give in a descending order. They indicate a long succession of distinct eruptions of pumice, which acquired a lodgement on the margin of the lake of Neuwied at a time when it was undergoing a comparatively rapid drainage :—

(*a.*) Superficial vegetable soil, 18 inches thick, but varying in different sites.

(*b.*) Six feet of white pumice.

(*c.*) A thin layer of vegetable soil, 2 inches thick.

(*d.*) Bed of pumice 18 inches thick.

(*e.*) 18 inches of soil mixed with darker coloured volcanic matter.—I am in doubt, as in a former instance, whether to attribute this volcanic substance to some late eruption of the crater of Laach, or to consider it as having been washed to this site by comparatively recent alluvial agents.

(*f.*) Two feet of white pumice and soil; the soil abounding.

(*g.*) A loamy and trassy bed, 6 to 9 feet thick, in which interspersed layers of pumice may be detected. This bed I must consider as chiefly formed by the substance of loess mixed with pumice-stone dust and lake mud. The loess does not appear to have been originally deposited in this site, but to have been washed into it from some adjoining place of lodgement, probably from the summit of the Nassburg.

(*h.*) The deepest and thickest bed of white pumice, amounting to six feet.

(*i.*) Deep bed, 18 to 20 feet in thickness, (described in page 182,) consisting of argillaceous loam, in which are contained fragments of lava, cinders, and tufa.

(*k.*) Basalt slag, &c., supposed to be a lava flow, which is at present quarried. The depth is unknown. (See page 127.)

This succession of eruptions of pumice appears, as we might expect, far less distinct in proportion to the distance to which we recede from the source of eruption. Thus, as we descend a valley towards Kehl, we find, superimposed upon a deep bed of gravel and soil, consisting mostly of fragments of clay-slate, an alluvial

deposit chiefly formed by the earthy matter of loess, and, above it, an alternation of pumice and loam, severally of the thickness of a foot, or a foot and a-half; while, over the whole, is a superficial coating of vegetable soil one to five feet thick.

And, lastly, when we reach the trass valley of the Bruhl, the appearances of pumice grow still more faint. A trifling dispersion of it has been observed near Tonistein, as well as on the banks of the Rhine, near Fornich.

(7.) *Dispersion of Pumice over the surface of the hill east of Eich.*

But we may now trace still greater accumulations of pumice in a direction more to the east of Eich.

About half-way between the Nickenicher Sattel and Andernach a hill intervenes, on the declivities of which the pumice has been drifted by westerly or south-westerly winds, apparently to a considerable depth. On the southerly declivity of this ridge beds of pumice appear to lie very deep, but the actual depth is not to be ascertained. Near the summit I observed the following section:

(*a.*) Twenty-four inches of superficial vegetable soil, mixed with fragments of pumice.

(*b.*) Fragments of pumice, mixed with shattered fragments of clay-slate, 18 inches thick.

(*c.*) A brown earthy and trassy loam, mixed with vegetable matter, 2 feet thick.

(*d.*) Bed some feet in thickness, the actual depth of which is not visible, of fragments of pumice mixed with small fragments of clay-slate, among which I detected some that had undergone an alteration from heat.

In another section at the summit of the hill, I observed the following succession of horizontal layers, which is given in a descending order:

(*a.*) Fragments of pumice mixed with vegetable soil which formed the superficial deposit. Thickness 6 feet.

(*b.*) Earthy matter, apparently composed in part of pumice-stone dust, with small fragments of pumice 7 or 8 inches thick.

(*c.*) Layers of pumice, mixed with fragments of greywacke slate, and even with dark-coloured volcanic matter, giving rise to the suspicion of a slight eruption from the crater of Laach having taken place. The thickness is 21 inches.

(*d.*) Two feet of earthy matter, (like (*b.*)) containing fragments of clay-slate and pumice.

(*e.*) Accumulation of pumice, the depth of which is unknown.

*(3.) Dispersion of Pumice nearer Andernach.*

Upon the northerly declivity of the high ground which intervenes between the Nickenicher Sattel and Andernach, sections of the drifted pumice become better exposed. Rather high up on this declivity I found the following series of beds:—

(*a.*) Superficial vegetable soil to the depth of 12 inches.
(*b.*) Fragments of pumice, mixed with vegetable soil, 3 feet thick.
(*c.*) A trassy substance, in rather a hardened state, which seemed in part composed of pumice-stone dust; about 6 inches thick.
(*d.*) Fragments of pumice in a bed of the thickness of 3 feet 9 inches.
(*e.*) Deposit of loess, of which a depth of 21 feet was exposed.

And, in another section near the Kirchberg, where the greatest accumulation of loess is apparent, the series of beds was as follows:

(*a.*) Superficial vegetable soil, 1 foot.
(*b.*) Fragments of pumice to a depth of 6 feet.
(*c.*) Trassy matter, apparently composed in part of pumice-stone dust, to a depth of 15 inches.
(*d.*) Thin layer of fragments of pumice 3 inches thick.
(*e.*) Another thicker layer, divided from the upper one by a thin coating of pumice-stone dust, near 2 feet thick.
(*f.*) Subjacent bed of loess.—The depth in this section is not apparent.

Below the Kirchberg, near Andernach, the drifting of the pumice is perhaps better studied than in any other site. A section of it has been described with much accuracy by M. Steininger, which I shall subjoin:

(*a.*) Superficial vegetable soil; 2 feet.
(*b.*) Pumice-stone fragments; 4 feet.
(*c.*) Earthy layer, in which pumice-stone dust is mixed; 4 inches.
(*d.*) Pumice-stone fragments; 1½ foot.
(*e.*) A trassy sort of layer of a yellowish-white colour, which seems ejected pumice-stone dust; ½ foot.
(*f.*) Pumice-stone fragments; 3 feet.
(*g.*) Trassy deposit, like *e*; 1½ foot.
(*h.*) Pumice-stone layers, mixed with fragments of clay-slate, 5 feet thick.
(*i.*) Deposit of loess.

But besides these accumulations of pumice in the vicinity of

Andernach, fragments of the same have been transported in the same north-easterly direction to all the low grounds in the vicinity of St Thomas's convent, and the Nette Muhle villa, as well as to the village of Leudesdorf, situated on the right bank of the Rhine, and even to the foot of the Westerwald. But the examination of such distant accumulations of pumice as appear to the north of the Rhine must be deferred, until the accumulations have been described, which were submerged beneath the waters of the ancient lake of Neuwied.

## Section II.—The later ejections of Pumice which fell upon the surface of the lake of Neuwied, and became submerged.

It is now necessary to add, that the attention must not only be called to the greater or less distance to which ejections of pumice were transported, but even to other circumstances relative to their accumulation in the form of beds.

Having in the last section described such accumulations of pumice as appear dispersed to the south and west of the lake of Neuwied, I shall, in the next place, consider such as upon being saturated with water became submerged, and thus formed the conglomerate strata of pumice which are quarried in the vicinity of Neuwied and Engers, as well as in other places.

It was, I believe, first remarked by M. Steininger, that the Rhenish pumice-stone swims so long as its pores are dry; and that it sinks so soon as its pores are entirely penetrated by water. Keeping this fact in view, we have only to conceive of pumice ejected from a volcano, and falling into streams, or upon the surface of the lake of Neuwied. The pumice, after floating for a short time, would sink by the mere penetration of water into its pores, but it would sink the sooner, if, after having fallen into a muddy stream, it should be likewise penetrated by sand or loam. Under such circumstances it is evident, that, in proportion to the continued activity of the volcanos which threw out pumice, a process would be going on by which a considerable sub-lacustrine deposit of this substance would be formed.

Such a deposit is accordingly to be observed occupying the ancient depths of the lake of Neuwied.

The age of the lowest strata of this deposit is not very appreciable. They have a date which may probably be referred to the close of the tertiary epoch. But this is merely conjectural, as it is difficult to estimate all the effects of the diluvial catastrophe, and to speak with any degree of certainty upon the probability of fragments of pumice, which had been washed into the basin of Neuwied, having had time allowed them to absorb into their pores so much water as would render them specifically heavier, and af-

terwards to subside to the bottom of the lake in the form of regular strata. It is more rational to suppose, that all, or most of the fragments of pumice which had fallen upon the surface of the flooded basin, would either float with the greatest rapidity along the current of the Rhine, and thus be eventually transported to the distant ocean, or would otherwise be entangled in the broken up beds of loess deposited by diluvial waters. That this latter circumstance took place is evident from actual appearances. Light fragments of white pumice are not unfrequently met with imbedded in the loess, though in sparing quantity.

Taking these circumstances into consideration, we must consider most of the submerged pumiceous strata as postdiluvian.

The site of the submerged beds of pumice, being on the right of the present channel of the Rhine from Neuwied to Engers, indicates the influence of south-westerly or westerly winds, as well as the conjoint aid of the Nette and certain streamlets, the direction of whose several currents has particularly favoured a deposition in this locality.

The adventitious earthy matter which has entered into the composition of the submerged pumiceous strata, is indicative of the older beds which subsisted on the margin of the lake at the time when this deposit was taking place. These beds consisted, *first*, of tertiary strata of sand and plastic clay; *secondly*, of beds of gravel; *thirdly*, of beds of black volcanic sand; and, *fourthly*, of diluvial beds of loess.

The earthy matter composed of sand and plastic clay, mixed with the bituminous matter of brown coal, which, since the diluvial catastrophe, was washed into the lake and became intermixed with submerged pumice, may be traced to the heights of Altweid, or even of Coblentz. It is difficult, however, among submerged strata of pumice, to detect this substance in particular, as it must be greatly mixed up with the substance of loess, which frequently it resembles.

Very little of the river gravel, as we might expect, is found among the submerged pumice-stone beds. The gravel, which continued to line the declivities of the hills, does not appear to have travelled very far into the depths of the lake.

The black volcanic sand of the basin of Neuwied, which had occupied the sides and depths of the lake, appears to be much mixed up with the substance of the submerged pumice-stone beds; —a circumstance which might be expected from the facility with which its finer particles would be transported.

But the substance which is no less blended with the submerged pumice, is that of the broken up beds of loess, which had been deposited in numerous sites upon the margin of the basin of Neuwied. By rains and currents it would be readily washed into the lake, and, from the extreme lightness of its particles, would be transported into all the depths and recesses of it, whence a considerable diffusion of its particles would be imparted to the lacustrine waters.

We are thus induced to suppose, that the showers of pumice, which long continued to fall upon the surface of the lake of Neuwied, did not become submerged by the water alone which had entered into their pores, but likewise by the finer particles of loess, which, in the muddy waters of the lake, were insinuated into them, aided by particles of black sand, and, in a still lesser degree, by the alluvial debris of the older tertiary beds of plastic clay and sand.

All these lighter adventitious matters have operated as a cement to the pumiceous fragments,—the cohering power of which has been increased by the addition of such pulverulent particles of pumice as have fallen into the lake, and have become diffused through it, and thus have been intermingled or blended with the other earthy matters which I have described.

Owing to these varied circumstances, a sort of alternation has taken place of the pumice-stone fragments with the finer diffused particles, which it will be necessary to explain.

Upon the pores of the larger pumice-stone fragments which had been washed into the lake becoming saturated with water, such fragments would sink in a stratum by themselves, while the light pulverulent particles ejected from volcanos, with which they were accompanied, would remain for a time suspended in the water, to be afterwards gradually deposited as a superimposed layer;—which process would be repeated as long as the eruptions were continued or renewed, until several alternations had taken place. But this would not be all the effect which would ensue. The effect of long immersion and pressure would be, that in any one layer the finer particles of pulverulent matter composing it would gradually insinuate themselves among the pumice-stone fragments constituting its subjacent layer, so as to form a medium of cement, and this process becoming general throughout the alternating layers, the result would be, that conglomerate strata would be produced, in which an internal character of alternation with finer particles would be preserved. To this explanation it is almost unnecessary to add, that these finer cementing particles would, according to circumstances, consist either of the molecules of pumice suspended by the waters, or of arenaceous, or loamy matter.

The cement by which this assemblage of pumice-stone fragments assumes a conglomerate form does not always occur in such a quantity as to fill up each vacant interval. On the contrary, many voids may be remarked which have imparted to the strata little consistency, an easy yielding to friction, and a comparative lightness, which is less even than water. It has been also remarked of these conglomerate beds of pumice, that, in some of them, the fine pulverulent particles so much prevail, that very few of the larger fragments of pumice-stone are contained in them.

The finer alternating layers thus formed are of variable thickness. Frequently, a layer does not exceed the fourth of an inch, while, more rarely, it may be rated at about an inch in thickness.

Lastly, with regard to the united thickness of the submerged pumiceous beds, it has not to my knowledge been estimated. It is said that the depth to which they have been quarried is twenty-four feet; but, from my own observation, it appeared more considerable.

After this explanation, I shall describe some few submerged pumiceous beds, as they are to be seen in the many quarries of it which have been opened;—the substance being in great request, more for its lightness than for its state of internal cohesion, as suitable for the inside walls of houses, or for the structure of chimneys.

Near Plaidt, beds of conglomerate pumice-stone appear close to the Humrichs, though in little quantity. Strata of this description have been described by M. Faujas St Fond, who states that they have the distinctive name given them of *Tauchstein*. They appear chiefly composed of fragments of pumice-stone, mixed with extraneous matters, which are cemented by pumice-stone dust. In the quarry they are cut by hatchets into the form of bricks.

Regarding the pumiceous strata of Neuwied and Engers, very ample details have been published. Of some of these I shall avail myself.

At Engers, the firmest beds of conglomerate pumice-stone which are worked, consist of rounded yellowish, and greyish white pumice-stone grains, cemented, rather loosely, by a compound of clay, dark sand, and other light earthy matters, much mixed up with pumice-stone dust. Sometimes the pumiceous grains are invested with this cement as with a capsule, and are thus rendered coherent. But this cement does not always fill the void spaces, whence the little consistency of this formation, its lightness, which is less than that of water, and its easy trituration with the hand.

With respect to the internal arrangement of structure exhibited

by these beds, they may be described as consisting of layers of pumice, cohering not only by the assistance of pulverulent or earthy matter, the substance of which serves as a medium of cement, but by fine interlaminæ composed of the same cementing ingredients, which vary from the fourth of an inch, or even less, to perhaps an inch in thickness.

The relations of these conglomerate beds to lower, or previously formed strata, I had not an opportunity of examining. It would appear, from an account given by M. Steininger, that beneath some darkish-coloured conglomerate strata of pumice, by which I understand layers of pumice alternated and cemented by the aid of volcanic sand as well as other matters, he observed a thick mass of loess, and, beneath the whole, gerolle, or gravel.

The deposits, by which the conglomerate strata of pumice were succeeded, appear to have consisted, *first*, of substances washed from the margin of the lake of Neuwied into its bed, apparently during the process of subsidence which its waters were undergoing; and, *secondly*, of a superficial soil which succeeded to the drainage of its waters. Thus, at Engers, I observed the following succession of beds, which I give in a descending order:

(*a.*) Superficial soil, two feet thick, consisting of light sand and clay, mixed with vegetable matter.—In another part of the quarry I found the surface much mixed up with the matter of loess, washed down from the margin of the ancient lake, which was of a yellowish brown colour, resembling in aspect and consistence the familiar substance of our Scottish snuff.

(*b.*) Layers of a mixed character, consisting of small fragments of clay-slate, swept from the mountains, of minute grains of siliceous sand, of dark volcanic sand, and of argillaceous and pumiceous particles, alternated with other layers of submerged pumice.

(*c.*) Conglomerate strata of pumice cemented by a mixture of pumice-stone dust, dark sand, and loess, having an interlaminated arrangement as before described. These lower beds are quarried.

And, in a superficial section at Engers, I found exposed other beds, by which the conglomerate pumiceous strata were succeeded. Nine feet of alternations of white pumice and dark-coloured sand were surmounted by ten feet or more of a yellowish-brown loamy substance mixed with vegetable soil. These ingredients, which were very irregularly distributed, indicating that they had been originally drifted to certain localities, in preference to others, by currents and other causes, had no doubt been subsequently washed from the margin of this ancient lake into its bed.

Another succession of beds, surmounting the conglomerate strata of pumice, is given in M. Von Leonhard's Taschenbuch, which I subjoin, with explanatory remarks:

(*a.*) Superficial soil, in which conglomerate strata of pumice are not developed. This bed appears to have been formed after the lake of Neuwied was drained.

(*b.*) Loess, of a loamy and sandy character, and of a greyish or yellowish-brown colour, mixed with an indefinite quantity of rounded pumice-stone fragments, severally not exceeding in magnitude ½ to ¾ of an inch, to which the loess often serves as an imperfect cement.—But, according to another account, strata of soil occasionally intrude.—This bed has probably resulted from substances washed from the margin into the bed of the lake during the subsidence of its waters.

(*c.*) Loose pumice-stone gerolle, 6 to 9 feet thick;—a submerged bed.

(*d.*) Rather firm strata of conglomerate pumice-stone which are worked. The lowest visible bed.

My account of such conglomerate strata as may be considered the result of ejected showers of pumice from the Humrichs, is at length concluded. We are at the same time entitled to expect, that much of the pumice which fell upon the surface of the lake was carried down by currents, and transported into very distant localities, either along the course of the Lower Rhine, or into the German Ocean. A late writer has accordingly stated, that indications of pumice may be detected at Xanten near Cleves; but I have not had an opportunity of confirming this observation.

## Section III.—The accumulations of Pumice which occur on the northerly confines of the Ancient Lake of Neuwied.

In describing the accumulations of pumice ejected by the various Humrichs, commencing with those which appeared to be the nearest to their several points of eruption, and ending with such as were transported to a greater distance, I have supposed a line to be drawn from the Humrichs of Saftig to those of Plaidt and Kretz, and thence to the Nickenicher Sattel. This line, from south by east, to north by west, indicates the site where more abundant accumulations appear, or where the individual size of the fragments ejected is the greatest. Afterwards, I noticed such pumiceous beds, or layers, as appeared to have been transported to a greater distance from this line of proximity, yet to have fallen upon the dry land to the south of the Basin of Neuwied, or between Andernach and Coblentz. And, lastly, I directed the attention to such showers of pumice as in their transportation to a

still greater distance must have descended upon the surface of the lake of Neuwied, and have acquired a greater specific gravity from the water and pulverulent matter which the fragments had absorbed within their pores, so as to become submerged and consolidated.

In the present section I shall examine such pumiceous fragments as were carried to a still greater distance, where they lie thickly strewed over the elevated grounds to the north of the ancient basin of Neuwied, and even upon the high declivities of the Westerwald.

In tracing accumulations of pumice from the city of Andernach, where deep beds of it appear, we find that showers of this substance were conveyed by westerly or south-westerly winds, not only to all the low grounds in the vicinity of St Thomas's Convent, and the Nette Muhle villa, but even to the hills across the ancient lake of Neuwied, namely, to those which rise near its gorge above the present villages of Leudesdorf and Fahr. Other fragments again, in deriving their origin, as well from the crater of Nickenich, as from the Humrichs of Saftig and Plaidt, appear drifted to a depth of many feet between Oberbieber and Bendorf. This is the line in which the deepest accumulations on the right bank of the Rhine are developed, but it by no means forms the remotest limits to which the pumice was conveyed.

It has been very perspicuously pointed out by M. Steininger, as well as by M. De Wyck, but more particularly by the latter writer, that the diminution of the size of pumiceous fragments is in proportion to the distance to which they have been conveyed. The result of these observations I shall now give.

It has been remarked, that at Plaidt the fragments of pumice are of the largest size, attaining occasionally a diameter of ten or twelve inches.

At a farther distance the fragments become smaller, acquiring the size of small pebbles, of not more than two or three inches in diameter. They are found, it is observed, of this magnitude at Andernach, Fahr, Weissenthurm, and Kettig, and among the submerged pumiceous strata of the basin of Neuwied, which are at present quarried near the towns of Neuwied and Engers.

At a still greater distance, the fragments are of the size of peas, and portions of half an inch in diameter are rare. Of this character is the pumice-stone at the Saynbach, and at the foot of the mountains near Romersdorf as far as Oberbeiber.

Again,—at points still more remote, as at Renzdorf, Honnefeld, Anhausen, and Neuhausel, the size of the pumice-stone fragments decreases in a most remarkable manner, shewing a transition to what is named pumice-stone *gruss*.

*Lastly*, at Langendernbach, the pumice, as it appears in the

sand-pits of this vicinity, is nothing more than pumice-stone sand or dust; the largest particles not exceeding the size of grains of barley.

The greatest distance to which the pumice has been transported, I have endeavoured to represent upon the general map. But I am not quite certain that this supposed limiting line is correctly traced, which, from various circumstances, must be too frequently obscure.

## CHAPTER XXX.

### THE COMPLETION OF THE DRAINAGE OF THE BASIN OF NEUWIED.

But we must now turn our attention from volcanic eruptions to notice the completion of the drainage of the basin of Neuwied. This final result suggests a brief recapitulation of the former states of the district which we have examined, and, in contrasting these with its present condition, we can scarcely avoid deriving from the comparison much profitable instruction.

We originally contemplated the basin of Neuwied in connection with that of the upper Rhine. In consequence of a barrier of high land stretching across the present site of the straits of Bingen, and thus filling up the small geographical space between the chains of the Hundsruck and the Taunus, this upper basin had no connection with the present channel of the Rhine from Bingen to Cologne, or farther north. The waters of this inland sea flowed in a direction from north to south, while its southerly extremity was conneeted with the other marine basins of Europe by means of narrow channels.

To the north of the marine basin of the Rhine existed the fresh water lake of Neuwied, fed by many streams; the principal of these being the Lower Rhine, which occupied a deep fissure produced during some extraordinary convulsion, and the Moselle. The present gorge of the basin of Neuwied, situated close to the city of Andernach, did not then exist, in the place of which a barrier of continuous cliff rose to a considerable height, by which the waters of the lake maintained a level of scarcely less than 800 feet above that of the present stream of the Rhine at Coblentz. An overflow from the lake of Neuwied was then discharged into a lower fresh water lake, which has been named the basin of Cologne, and thence into the ocean which washes the shores of the British islands.

During the commencement of the tertiary epoch, the Lower Rheinland presented the appearance which is represented in the following page.

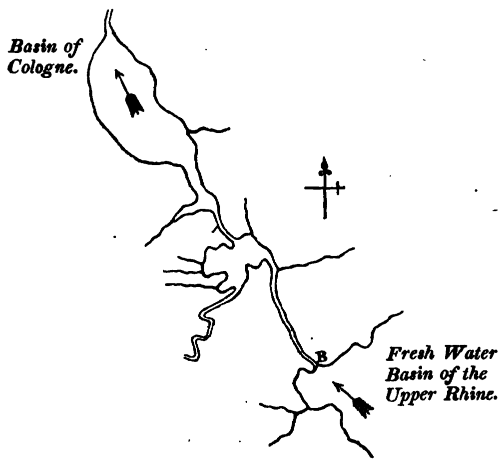
THE ORIGINAL STATE OF THE LOWER RHEINLAND.


Eventually, in consequence of the long and formidable waste which the rocks of Europe were undergoing, accumulations of debris had blocked up the narrow channel by which the marine basin of the Rhine was connected with the great Mediterranean Sea of Europe, and it became a fresh water lake. At the same time the basin of Neuwied, by the wearing down of the barrier of Andernach, had its waters reduced considerably in their level, which at the close of the tertiary epoch did not perhaps exceed a height of two hundred feet above the present level of the Rhine. And, with regard to the lower basin of Cologne, it is not improbable that a still greater diminution ensued, by which it admitted the waters of the ocean.

But we must now still farther change the scene. The great incident which in the Lower Rheinland marked the close of the tertiary epoch was the diluvial torrent, which derived its origin from the convulsive operations which were elevating the high chains of the European Alps. This catastrophe consisted in the inversion of the current of the basin of the Upper Rhine, which, instead of flowing from north to south, now began to flow from south to north. The waters then deepened for themselves a new channel through the narrow geographical space intermediate to the chains of the Hundsruck and the Taunus, whence was induced the present straits of Bingen. These changes have been elucidated by another diagram, (again subjoined,) where the arrow, which in the last geographical sketch shewed that the ancient waters of the

Upper Rhine had originally flowed from the present site of Mayence to Basle in a course of north to south towards the great inland sea of Europe, became inverted, so as to indicate the changed direction of their current from south to north, which, in other words, had the same destination as that of the waters of the basins of Neuwied and Cologne. During this operation, the diluvial torrent broke up the fresh water strata of *loess* which were deposited in the upper basin of the Rhine, and, in the rapid and violent drifting of these beds to lower levels, the transported matter appears to have blocked up the gorge of Andernach, whence was restored for a short period the ancient high level of the waters of the lake of Neuwied.

THE STATE OF THE LOWER RHEINLAND SUBSEQUENT TO THE DILUVIAL CATASTROPHE.



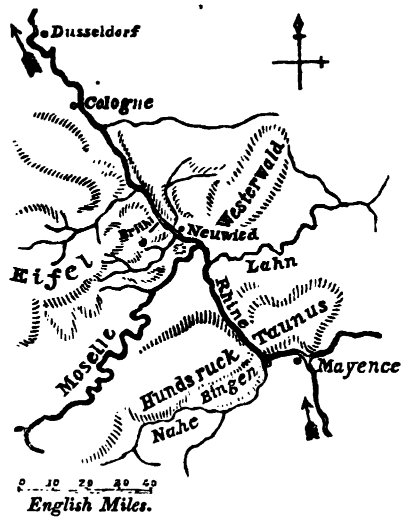

[In this sketch the letter B signifies the site where the waters, in descending from the basin of the Upper Rhine, rushed into the channel of the Lower Rhine at Bingen.]

But our history now draws near to a close. During the continuation of the eruptions of pumice, which had probably comprehended a considerable interval of time, the drainage of the basin of Neuwied appears to have arrived at its completion. This was occasioned by the immense deposits of loess which had blocked up the gorge of Andernach having been gradually washed away, and by the further gradual wearing down of its barrier of schistose rocks. The lacustrine expanse of Neuwied then became obliterated, and one continuous narrow stream, deriving its source from the high Alps of Europe, flowed peacefully through the drained

valley, where a new verdure began to subsist, preparatory to the fertile abode which it afforded for a hardy Teutonic race of inhabitants, who had ultimately emigrated thither from the shores of the Caspian.

This altered state of the Lower Rheinland, such as it shews itself to be at present, becomes most interesting when compared with the preceding geographical sketches.

THE PRESENT STATE OF THE LOWER RHEINLAND.




During this last and completed process of drainage, which the basin of Neuwied had undergone, it is probable that a considerable portion of the various substances, which, as formations, had filled the basin of Neuwied, became removed by the waters, which, at their present level were pursuing their course to the German Ocean. Indeed, it is impossible to traverse the Lower Rheinland without being convinced, that only a small portion remains of what was once a considerable deposit.

This drained state of the country was no doubt succeeded by an ameliorated climate. *

* With the mean temperature of the basin of Neuwied I am unacquainted. It is probably not far different from that of the neighbouring district of Treves, elevated at 485 feet above the level of the sea, which has been estimated at 7°.89 of Reaumur. At an elevation of 1700 feet above the sea, the mean temperature has been rated at 6° of Reaumur.

# CHAPTER XXXI.

## THE CESSATION OF ERUPTIONS OF PUMICE.

Eruptions of pumice, which, at the close of the tertiary epoch, commenced from older volcanic fissures, have been considered as continuing, with perhaps occasional interruptions, during a long interval of time subsequent to the diluvial catastrophe. That the activity of the volcanos from which pumice became ejected was prolonged to historic times, we have no reason whatever to suppose. Very forced interpretations of a passage in Tacitus, as well as very ambiguous circumstances connected with the discovery of a coin of Vespasian in the pumice of Bendorf, have been adduced to prove, that eruptions of pumice took place so late as the time of the Romans. To the invalidity of this evidence I shall advert in a subsequent chapter.

It would thus appear that the prolonged existence of active volcanos in the basin of Neuwied cannot, with any degree of plausibility whatever, be referred to historic times. A question may therefore fairly arise, whether it did not immediately precede, or, indeed, whether it was not coëval with the first peopling of this valley by the human race, though previous to the visit of the Romans? In this case it is very possible, that traditions of ancient volcanos might have been either so faint as not to be an object of notice by a civilized people, or that they might have been altogether lost. But these are merely conjectures. The plain and direct fact must not be lost sight of, that the extinct volcanos of the Lower Rheinland are totally uncommemorated by Roman historians, and hence their latest activity rather points to a period long before the visit of Cæsar, which was fifty years before the Christian era, or even long before the peopling of the country by Teutonic tribes.

But although eruptions of pumice have wholly ceased, gaseous exhalations, or *mofettas*, and mineral wells, most of which in their earliest developement must be considered as having had a date of origin fully as remote as that of the volcanic explosions, or convulsions, with which they were first coincident, have continued to survive, and to form the only indications at present subsisting, with perhaps the exception of a few occasional earthquakes, that the volcanic energy is not wholly inactive.

The mofettas and mineral wells of the basin of Neuwied might have been treated of in this chapter, if it were not for the uncer-

tainty of date in which the origin of most of them is involved. With more consistency, therefore, a notice of them will be deferred, until I am required to explain the natural changes which since historic times have been going on in the basin of Neuwied.

## CHAPTER XXXII.

### THE CHANGES EFFECTED UPON THE SURFACE OF THE ROCKS AND SOIL OF THE BASIN OF NEUWIED BY ITS SUCCESSIVE INHABITANTS OF THE HUMAN RACE.

In the present chapter the functions of the geologist expire, and those of the civil historian commence. As I am aware, therefore, that an extended prosecution of the inquiry which I have proposed is totally incompatible with the proper investigation to which I have confined myself, I shall do little more than take a very general glance at the leading changes effected upon the surface of the rocks of the basin of Neuwied, or upon its soil, by its successive possessors of the human race.

### Section I.—The changes effected upon the surface of the rocks and soil of the basin of Neuwied by its earliest recorded inhabitants.

The earliest inhabitants recorded by history as inhabiting the basin of Neuwied are the Ubii, who are supposed by some antiquaries to have occupied both sides of the Rhine. They may be considered as a Teutonic people.

It would be nothing more than conjectural to state the alterations which this early race of inhabitants might have effected upon the rocks and soil of the basin of Neuwied. To one very possible change, however, I shall certainly allude. The extreme facility with which tufaceous rocks are excavated have, in many parts of Europe which I have visited, recommended artificial caverns as dwelling places to many early tribes of Europe. Of this fact I have collected decided proofs in the central volcanic provinces of France, and also in Italy. It is rational, therefore, to suppose that the ancient Ubii would, in like manner, avail themselves of such soft tufaceous rocks as those of the Gansehals, of Bell, of the valley of the Bruhl, or of Kruft, to form for themselves convenient habitations, particularly when from the hunting they were passing into the pastoral state;—a condition of society into which they had entered when first visited by the Romans.

## SECTION II.—THE CHANGES EFFECTED UPON THE SURFACE OF THE ROCKS AND SOIL OF THE BASIN OF NEUWIED BY THE ROMANS.

The Romans entered the basin of Neuwied about fifty years before the Christian era. Cæsar, by whom they were conducted, was then undertaking a hostile expedition against the Catti and the Sigambri, who occupied the country north of the Maine, and east of the Rhine. The Ubii were his allies, and, with their concurrence, he built his celebrated bridge of wood over the Rhine, (near the Weissenthurm, as is supposed,) with the view of conducting his army against the Sigambri, who were posted upon the Sieg, and against the Catti, who were stationed near the Lahn. After the defeat of his enemies, he destroyed the bridge which he had formed, that it might not be employed against his allies.

A few years after this expedition, the Romans, in order to secure the country they had vanquished, found it necessary to form a permanent settlement in the basin of Neuwied. The Ubii then, by mutual agreement, ceded to the Romans the right bank of the Rhine, and themselves occupied the opposite side of the river.

During the earlier settlement of the Romans in the basin of Neuwied, various cities and forts appear to have been raised by them; a splendid one named Victoria, built in an elevated plain, near the present village of Niederbieber, and about a league distant from the Rhine; while a second town, not very far distant from Victoria, the Rigodulum of Ammianus Marcellinus, was situated near Engers.

These two cities met with a disastrous fate. In the time of Gordianus, when the power of the Romans was beginning to decay, the greater and lesser states of Northern Germany, under the names of Franks, or Free Men, and Alemanni, united to avenge themselves; and, by these barbarians, the Roman towns on the Rhine were, in the middle of the third century, probably about the time of Gallienus, surprised, destroyed by fire, and levelled to the ground. Teutonic tribes then took possession of the basin of Neuwied, by whom the city of Andernach, so named from a small brook, the Andert, which washed its walls, appears to have been inhabited.

In the year 359 Andernach was taken by the Emperor Julian, in his expedition against the revolted Germans; and, being considered by the Romans as an important station, was occupied, increased, and adorned by them, and under the various names of Anternacum, or Antenacum, became the residence of a military prefect.

This is the brief history of the settlement of the Romans in

the basin of Neuwied. From the commencement of their visit, we must consider the lava of Mennig, together with the tufaceous deposits of Kruft, Brühl, and other places, as first undergoing, for the purposes of architecture, incidental to the new Roman settlement then forming, extensive operations of quarrying, by which the surface of these rocks began to suffer artificial changes of no little importance.

The lava of Mennig was conveniently worked by the Romans in the deep fissure caused by an extraordinary convulsion of nature before described, (see page 206,) through which a small stream now finds a passage. Traces of ancient quarries are found near the village of Niedermennig. It was in chief request, on account of its hardness and other qualities of durability, for the architecture of bridges, having, in the first place, been employed for the construction of a permanent one across the Rhine, near to the present site of Engers. This important use which was made of the Mennig lava, caused it in a subsequent period to be sent to so great a distance as Treves, where it was employed in the foundations of the solid bridge which crosses the Moselle.

Another purpose for which the lava of Mennig became quarried, was suggested by the familiar use which the Romans had made of a similar rock, in their own volcanic country, for the construction of portable millstones or hand-mills:

> Quin etiam variè quædam sine nomine saxa
> Toto monte liquant; illis custodia flammæ
> Vera, tenaxque data est; sed maxima causa molaris
> Illius incendi lapidis sic vindicat Ætnam.
>
> Ætna Cornelii Severi.

So soon as it was known that a quarry had been opened in the country of the Ubii, and that a stone might be procured resembling such lavas of Italy as were adapted to the purpose of millstones, the demand for it in the Roman stations became general. An intelligent antiquary and naturalist, W. C. Trevelyan, Esq. of Wallington, has informed me, that he procured a portion of a Roman millstone, composed of the lava of Mennig, from the remains of a villa in Northumberland, near the Hunnum of the ancients. In the Roman station also of Aldborough in Yorkshire, the Isurium of Richard, the portable mills which have been found, show that the same use was in other places made of the lava of Mennig.*

The lava of Mennig was likewise in demand for the stronger arches which were used in the public or private edifices construct-

* My friend Mr Trevelyan, whom I have to thank for this curious information, presented me with a small specimen broken off from a millstone found near the Hunnum of the Romans, which I am fully persuaded may be referred to the peculiar lava of Mennig.

ed by the Romans, while they were forming a permanent settlement on the right bank of the Rhine, near the present site of Bieber, where a camp was giving rise to a flourishing city. Columns also, of various proportions, constructed from the Mennig lava, have been observed, which once belonged to the city of Victoria.

These were the chief uses to which the lava of Mennig was doomed during the time of the Romans. The tuffstein of the basin of Neuwied seems to have been devoted to no less frequent requisitions.

The deposit of tuffstein the most quarried by the Romans was that of Kruft and Plaidt. At Kruft (the name of which is said to signify a cavern or grotto) ancient works have been found, while at Plaidt even deeper excavations have been discovered, where tradition still assigns to the Romans the quarrying of their tuffstein.

It was perhaps in a later period of their settlement that the Romans seem to have extensively quarried the tuffstein of the trass valley of the Bruhl. The name of Tonistein (according to French antiquaries, *Pierre d'Antoine*) is supposed to indicate the use which Antonius, a later Roman prefect, made of this stone. Excavations have in this valley been detected, where, a few years ago, two votive stones were discovered, dedicated to Hercules Saxanus.

The tuffstein appears by the Romans of Victoria to have been used for all purposes to which bricks were applicable; as in buildings where extraordinary firmness and durability, such as bridges demanded, might be dispensed with;—or where, in otherwise strong buildings, a coating of well-shaped and symmetrical materials was deemed essential to ornamental architecture; whence the application of quadrangular portions of tuffstein to the coating of the beautiful Roman Tower of Andernach.—In cases where the tuffstein was demanded for security against external violence, it was raised from the quarries in large blocks: Thus, among the ruins of Victoria considerable masses made up the structure of the entrances, one of which was 5 Rhenish feet long; 2 feet 7 inches broad; and 2 feet thick. The tuffstein was likewise considered well adapted for the formation of the low pillars of a Roman hypocaust;—and, lastly, it was extensively used for votive altars and sarcophagi.

No other quarries in the basin of Neuwied appear to have been wrought by the Romans, with the exception perhaps of those of the plastic-clay of this vicinity. Fragments of earthen-ware, or pottery, have been found among the ruins of Victoria, which are said to rival the fabric of a Wedgwood.

Such were the changes effected upon the surface of the rocks

of Neuwied, or upon its soil, by the Romans. The city of Andernach was the last station of the army of the Lower Rhine. In the defence of the gorge, or pass, of Andernach, the Roman soldiers seem to have formed for themselves subterraneous dwellings near the present site of Fornich, which were either scooped out of the old beds of loess, which during the diluvial catastrophe had blocked up the gorge, or out of more solid rocks of clay-slate. In one of these subterranean dwellings was found an altar, the inscription of which bore, that it was raised by two soldiers of the thirty-fifth victorious legion.—" Finibus, et Genio Loci, et Jovi Optimo Maximo."

## Section III.—The artificial changes effected upon the surface of the rocks, or upon the soil, of the basin of Neuwied, during the middle ages.

Upon the retirement of the Romans from the Rheinland, who are supposed to have never completely subjugated this country, the basin of Neuwied, among many other districts of Germany, remained in the indisputed possession of the Franks, whose farther eruptions and concentrations in Gaul, are said to have been induced by the encroachments of the Saxons. An empire of the Franks was then constituted, which Clovis, upon his death, divided among his four sons. The eastern part of the empire, which had Metz for its capital, and in which the basin of Neuwied was included, acquired the name of Austrasia.

Pepin, as it is well known, not only succeeded in obtaining the crown of Austrasia, but again united to it the whole of France. And, in the year 800, Charlemagne, the son of Pepin, was crowned by the Pope, Emperor of the Romans, or of the western empire.

After this event there occurred considerable political changes and divisions, until the German branch of the race of Charlemagne became extinct in the male line, when a general diet of the five nations of the Franks, Swabians, Bavarians, Saxons, and people of Lorraine was convened, to appoint a successor to the German empire; and thus, the sovereignty became elective, but was commonly retained in the same line. In the course of time, great inconvenience was sustained from the number of electors, and a few only were appointed, among whom, in the Rheinland and its vicinity, were the Archbishops of Mayence, Treves, and Cologne. The basin of Neuwied was included in the electorate of Treves.

From this period the dominions, or estates, which were comprehended within the realm, became at the disposal of the emperor, from whom emanated secular dignities, as well as the confirmation of the great fiefs. Each petty prince, or lordling, then became

arbitrary in the management of his own limited district, and the greatest oppressions and spoliations ensued.

It was at this time that the basin of Neuwied underwent a striking alteration in its character, and general complexion. The marauding barons, numbers of whom settled in this small district, selected for the sites of their strongholds, many insulated peaks afforded by the irregular surface presented by schistose rocks, or by the trachytic or basaltic eruptions with which their summits were capped.

Among the outjutting and elevated cliffs of clay-slate which were selected for the sites of castles, may be reckoned that of Ehrenbreitstein, where a burg was erected for the occasional residence of the Archbishop of Treves, or of Hammerstein, situated on the right bank of the Rhine, near the gorge of Andernach. The latter was the ancient seat of the Lords of Nuringen and Hammerstein;—in the 11th century it belonged to Count Otto of Weteravia;—Henry the Second seized the castle because it was at war with the Archbishop of Mayence; and to this stronghold Henry the Fourth, during his flight down the Rhine in the year 1105 found a shelter;—in the 14th century Hammerstein was granted to Cuno, Elector of Treves.—But the history of these castles is not demanded in this memoir. It is sufficient to add, that other convenient sites which the irregular surface of clay-slate rocks afforded for petty feudal tyrants, who from these heights descended to levy their exactions, (analogous to the black mail of Highland chieftains and nobles,) or to plunder the unwary merchant on his journey to the fairs,—may be mentioned the castles of Burresheim and Virneberg.

Many trachytic or basaltic eruptions, likewise, which overtopped bold eminences of clay-slate, invited, by the natural defence which they offered, suitable sites for castles. Upon the volcanic eruption which crowns the summit of Olbruck the foundations of a noble castle were reared, the angular keep of which has a base of the dimensions of forty-five by thirty feet, with a tower which at a conjecture I estimated at nearly 170 feet in height. The Nurburg, bordering upon the district of the Eifel, exhibits a second bold volcanic peak, which was selected as the site of a strong castle. Among other equally formidable sites which were similarly availed of, might be mentioned that of Werner's Eck.

Nor have rocks of tufa been excluded from being the sites of burghs, or forts, of which the ancient castle of Schweppenburg, near Burgh Bruhl, formerly belonging to the Counts of Metternich, is an example. Owing to the facility with which the substance of the cliff could be excavated, spacious caverns and halls have been hollowed out subservient to the use of the castle and its garrison.—It may be also remarked, that a similar convenient application of such rocks of tufa as have been selected for castel-

lated sites, is a familiar one in the provinces of Auvergne or Velay, in central France.

But, if the whole of the Lower Rheinland appeared bristled with castles, by which the dearest rights of the citizen were disregarded, while insolence and barbarity triumphed, there was still an antidote preserved in the monastic institutions which yearly sprang up, to which the dawning light of revived science and freedom fled in dismay. "Where," asks an elegant writer, "could the previous remains of classical learning, and the divine monuments of ancient taste have been safely lodged amidst the ravages of that age of ferocity and rapine which succeeded the desolation of the Roman empire, except in sanctuaries like these, consecrated by the superstition of the times beyond their intrinsic merit? The frequency of wars, and the licentious cruelty with which they were conducted, left neither the hamlet of the peasant nor the castle of the baron free from depredation; but the church and monastery generally remained inviolate. There Homer and Aristotle were obliged to shroud their heads from the rage of Gothic ignorance; and there the sacred records of divine truth were preserved, like treasure hid in the earth in troublesome times, safe but unenjoyed." *

During the middle ages, several monastic buildings were raised in the more secluded vallies of the basin of Neuwied. In the year 1093, Henry the Second of Laach, first Count Palatine of the Rhine, selected the beautiful margin of the lake of Laach for the foundation of a noble abbey, which he richly endowed, while in a subsequent period the resources of the institution were increased by other munificent benefactors. This abbey, dedicated to the Benedictine order of monks, was long celebrated for its hospitality. A principal aisle was consecrated to the use of the stranger, while another department was devoted to the poor and the sick. A rich library was preserved within its walls, which contributed to the dawning cultivation, in the Lower Rheinland, of the liberal arts and sciences.

When the religious edifice of Laach was raised, the lake in its constitution underwent some little change. In order to obviate the effects of a sudden rise of the waters, by which the safety of the building might be threatened, the monks contrived to discharge its overflow by a narrow canal.

Other monastic structures likewise appeared, of which one was subsidiary to that of Laach, namely, the abbey, situated within the extinct volcanic crater of Wehr; a second was the retreat of Carmelites, almost concealed beneath steep cliffs of schistose rocks,

* Essay on Monastic Institutions in "Miscellaneous pieces in prose, by J. A. and L. Aiken," p. 91.

or of tuffstein, in the trass valley of the Brühl;—a third was the convent of St Thomas, near Andernach, founded in the twelfth century by Tennevide, Countess of Sponheim, who was the first abbess;—while a fourth was a Benedictine abbey situated at Romersdorf.—But this list might be much extended.

The chapels which were reared on the soil of the basin of Neuwied during the middle ages are far too numerous to be recounted. The finest specimens of them are to be found in the cities of Coblentz and Andernach. The chapel of St Genevieve, named Frauenkirk, was not a little celebrated, where, according to the romantic legend of this holy dame, her remains lie interred.

During the middle ages some important cities were contained within the basin of Neuwied. Of these Andernach was the most ancient and the most renowned. It was included in the cities of the Rhine, which in the thirteenth century had leagued to defend themselves against the power of the marauding barons. Andernach could then furnish within her walls ten thousand well-armed foot soldiers, and fifty cavaliers. A noble castle, a lofty tower, and strong inclosing ramparts still attest her ancient strength.—Coblentz, where the Romans had a castrum, was fortified, and became an occasional residence for the kings of France and of Germany down to the time of Louis of Bavaria.—Engers was fortified by the Archbishop of Treves, who built a castle and a tower for the protection of the Rhine against feudal brigands;—this defence had been suggested by the plunder which some Flemish merchants had encountered in their route to the fair of Frankfort.

From this brief history, may be collected the more general changes which the rocks and soil of the basin of Neuwied at length began to exhibit on their surface. The bolder eminences were overtopped by lordly castles:—within the most sequestered vallies of disruption, or within the compass of extinct craters, monastic buildings were concealed;—while, upon the plains, numerous chapels invited the laity to the solemn duties of religion.—Lastly, the well-fortified town of Coblentz appeared at the entrance of the basin of Neuwied, where the waters of the Rhine and the Moselle meet in confluence, while a still prouder city, that of Andernach, graced its ancient gorge.

During this period the various rocks and strata of the basin of Neuwied were extensively quarried. Primary schistose strata, assisted by trachytic or basaltic rocks, afforded the chief materials for the strong castle of the baron.

The lava of Mennig and other places continued from the time

of the Romans to be in chief request for the construction of bridges, as is exemplified in the ancient bridge of fourteen arches which crosses the Moselle at Coblentz:—it was built by Bishop Baldwin, brother of the Emperor Henry the Seventh, and by Boemund the Second, the expences of which were defrayed by sale of indulgences.

The earliest abbeys of the basin of Neuwied are supposed to have been erected out of the materials of the destroyed Roman towns. In the abbey of Romersdorf granite and marble pillars, foreign to the basin of Neuwied, are detected:—these had been transported from considerable distances by the Romans to grace their temples, their forums, or even their private dwellings. In other requisitions, the older schistose rocks, as well as trachyte, basalt, or tuffstein, were variously employed.

For the use of millstones, the lava of Mennig continued to be celebrated. It was worked for this purpose during the whole course of the middle ages.

## Section III.—The artificial changes effected upon the surface of the Rocks, or upon the Soil of the Basin of Neuwied, during modern times.

But I have now to state the still greater changes which the surface of the rocks and soil of the basin of Neuwied were doomed to undergo in modern times.

This period in the Lower Rheinland was first marked by the flames of war and desolation. During the memorable campaign of thirty years, Hammerstein, an important post, was taken by the Swedes, retaken by the Spaniards, and eventually, in the year 1650, demolished by the Elector Philip. Andernach, in the year 1688, was burnt by the French, and, in 1758, the Castle of Engers was demolished. But the greatest change followed the French revolution. The Basin of Neuwied then exhibited every where the flames of war. In 1796, the French attempted to pass the Rhine near Weissenthurm, where it had been first crossed by Cæsar, but were opposed by the Austrians, who were here defeated. A monument still remains on this site, celebrating the name of the general under whom the French were led to victory. "*L'Armée de Sambre et Meuse à son General Hoche.*"

But the greatest change which accompanied the irresistible advance of the French, was the destruction which befel the most ancient feudal and religious establishments.

The object which the confederative towns of the Rhine could feebly succeed in achieving, was speedily effected by the revolutionary spirit of this period. The castles which had survived earlier checks to feudal tyranny, now lost for ever that power which had seldom been exerted but for the most despoiling and

profligate of purposes. In my recent visit to this country, I observed towers which forty years ago had retained their ancient strength, now presenting little more than a dilapidated heap of deserted walls.

A change no less great was the fate of ancient religious institutions. "After all that can be said in favour of monastic institutions," remarked the elegant writer whom I have before quoted, who wrote some few years previous to the French revolution, "we have reason to rejoice that the superstitions of former times are now fallen into disrepute. What might be a palliative at one time, soon became a crying evil in itself. When the fuller day of science began to dawn, the monkish orders were willing to exclude its brightness that the dim lamp might still glimmer in their cell. Their growing vices have rendered them justly odious to society, and they seem in a fair way of being for ever abolished."

This prophecy, ten years after it was penned, became fulfilled wherever French arms, or French principles, had made a successful advance. In the basin of Neuwied, St Thomas's convent near Andernach was by the French armies burnt. The suppression of other convents and abbeys followed, and, as a climax to the whole, the sale of the ancient and long-celebrated Abbey of Laach was in the year 1820 effected to the best bidder. The fate of the noble walls of Kloster-Laach, not only the antiquary, but every individual of even ordinary taste, must for ever deplore. The abbey and the lands adjoining became converted into a farm;—the kitchen was metamorphosed into a distillery, and the refectories into stables. The church, within which many noble families reposed, now presents a scene of disgraceful ruin; while its fairest monuments have, by neighbouring Vandals, been wantonly destroyed. It is stated, that, upon a large table in the hall of the chapter-house of Laach, was inscribed the following lines, which are now regarded as a fulfilled prophecy:

> Quas sacras ædes pietas construxit avorum
> Has nunc heredes devastant more luporum.

In the year 1829, the destruction of the ancient convent of the Carmelites, near Tonistein, ensued; the materials of it having been sold for what they were worth in a demolished state. I witnessed its destruction, which recalled the scenes of which I had read, incidental to the abolition of the monastic orders in England, when architectural strength or beauty made an ineffectual appeal to tasteless and sordid reformers.

But if, in modern times, war and revolution have changed the scene which the basin of Neuwied anciently presented, it is some pleasure to think, that a truly reforming and liberal spirit has in one instance advanced more silently, and with better taste. In the year 1737, a new town was projected by Count Frederic Wil-

liam of Neuwied; and, as a motive for settling in it, a free toleration was granted for all religious sects. The experiment, as might be expected, was crowned with success, and the town of Neuwied has at length become one of the most flourishing settlements of the Lower Rhine.

After this slight history, I shall now take a glance at the changes which modern art and industry have effected on the surface of the basin of Neuwied, which are exemplified in its quarries of clay-slate, in its plastic clay and brown coal pits, in its millstone and tuffstein quarries, or in the agricultural changes effected upon its soil.

*(a.) Quarries of Argillaceous Schist.*

The primary schistose rocks of the basin of Neuwied are now quarried for the minerals which they contain. I learn from Schrieber, in his work upon the Rhine, that forges and *martinets* for iron have been established at Nothhausen, at Nettenhammer, near Missenheim, and at Sayn. It is said, that, at the last place, the iron obtained is the best in Germany, and as good as the Swedish.

*(b.) Plastic Clay Pits.*

The earlier tertiary deposit of the basin of Neuwied is much worked, on account of the esteem in which the plastic clay is held. The extraction of the purer clay, which is in great demand as a pipe-clay, or as a potters' clay, takes place in deep pits at Ochtendung, the lake of Laach, Bannerhof, Dreckenich, and at various other places.

The following description of the mode in which the pipe-clay is worked, I have extracted from a publication entitled, "Gemälde von Koblenz; Mainz, 1822."

"Opposite the village of Niederfell, a customary landing-place for market vessels sailing between Cochem and Coblentz, Gondorf is situated, where the hereditary castle of the present Prince Von Der Leyen is observable. Here the pipe-clay is loaded, which is dug at Dreckenich, a village situated a league beyond Gondorf. The bed of pipe-clay found here is the most important and interesting on the left bank of the Rhine. It is white, inclining somewhat to grey, and of a very good quality. In working the excavation, there is a shaft sunk by which beds consisting of gravel are cut through. When the pure potters' clay is approached, a round chamber is dug out below the shaft, the walls and base of which exhibit a continuation of circular measured terraces, which leave a deepening in their centre. There, the water collects, which penetrates the length of the shaft, and which the workmen make use of to moisten the clay that they have cut through, after it has been

loosened with a hatchet. The clay is then fashioned into small quadrangular lumps, which are extracted from the pit in barrels. This quarry of potters' clay, with its produce, employs through the whole year fifteen persons. It is exported in considerable quantities to various places; by the Moselle to France; or down the stream to the neighbourhood of the Lower Rhine, and to Holland, where it is employed in earthen-ware and tobacco-pipe manufactories."

### (c.) *Brown Coal Pits.*

The brown coal deposit, which is imperfectly developed in the basin of Neuwied, has long been in popular use as a fuel, while the variety named the earthy brown coal, procured near Bonn, has been worked for the valuable pigment named Terre d'Ombre, burnt umber, or Cologne earth. But, of late years, the brown coal beds have acquired more importance from their ingredients affording the materials for the extensive alum-works of the Lower Rheinland, as well as for the iron vitriol which is yielded by the abundance of their contained pyrites, to the preparation of which the bituminous matter of the brown coal beds is rendered subservient. Near Altwied, deep shafts have been sunk in the tertiary strata of the basin of Neuwied, but far more extensive alum and iron works are in the neighbourhood of the Siebengebirge. The most powerful strata of this last named deposit, belonging to the lower fresh water basin of Cologne, were found out nearly forty years ago, and it is honourable to the Rheinland to record, that a handsome monument has been erected near the mines as a tribute to the humble individuals to whom the country has been indebted for the discovery. From this memorial I copied the following inscription: DEM ANDENKEN DES ERSTEN FINDERS DER HARDTER BRAUNKOHLEN-LAGER, JOHANNES KIRSCHBAUM UND SEINER EHEFRAU ANNA MAGDELENA LÜTZ. [To the memory of the discoverers of the Brown Coal deposit of the Hardt, John Kirschbaum, and his wife, Anna Magdalena Lütz.]

This tribute displays the popular feelings of the district, and is strikingly contrasted with the neglect which is exhibited on the British shores for even far more important benefits; a neglect which is now operating to the serious prejudice of the kingdom, by annually thinning the ranks of useful or scientific contributors.

### (d.) *The Lava quarries of Mennig and other places.*

Of greater importance than the plastic clay or brown coal beds of the basin of Neuwied are the millstone quarries of Mennig, as they are wrought in modern times.

The best Mennig millstone is described as very hard; as emit-

ing, when beaten, a tinkling sound; as giving fire when struck with steel; as of a dark grey colour; as exhibiting pores, or cavities, partly long, like rents, and partly oval, like those which are found in pumice. It is further added, that the more porous the stone is, the more useful it is for millstones, as its surface continues even during the process of wear,—remaining rough and sharp like a grater.

The portion of the Mennig lava which is quarried for millstones is, by its divisionary structure, disposed into the form of columnar masses. A column of this kind is horizontally cut; while each section or portion has its angles rounded off to be formed into a millstone.

The upper portion of the Mennig lava, about seven feet in vertical depth, is not adapted for millstones, its internal pores being inconsiderable, while its columns are too small. It is rather the central portion of the mass, the extent of which is from 15 to 40 feet, that is the great object of the quarry. At a greater depth the divisionary structure disappears; the lava at length appearing as one solid mass.*

The working of the lava of Mennig, which had its origin in the time of the Romans, is now carried on to a far greater extent than ever. A good description of the mode in which the quarrying is conducted may be found in a memoir of M. Faujas St Fond, published in the first volume of the "Annales du Museum d'Histoire Naturelle," p. 184 to 190, from which I shall make an abstract:

"When it is intended to open for the first time a quarry upon a virgin site, (*emplacement vierge*,) there is traced upon the ground a circle of 24 to 25 feet in diameter, and, from the whole of this contained surface, earth to the thickness of a foot is stripped and removed to a certain distance, in order to form a *talus*, which serves to support the species of axle trees, or appointments, proper for elevating the millstones, and for raising them out of the quarry.

"While the earth is gradually taken away, a small and very narrow circular road is, with much art, shaped after the manner of an easy spiral staircase. This is made proportional to the advanced state and deepening of the aperture, which, in order to give to the work more solidity, is after the form of a reversed cone, or of a funnel. This labour is conducted with as much intelligence as perfection and economy; the declivities are so gentle and so regularly constructed, that children of a tender age descend with smiles these winding staircases, and carry up in baskets, with the same gaiety, the earth which the workmen detach. Thus, after

* This general character of the workable or unworkable portions of the Mennig lava is well explained in Dr Daubeny's Treatise on Volcanos, of which description I have in part availed myself.

much time and perseverance, five or six united families, who reciprocally assist each other, succeed in forming a truncated cone 24 to 25 feet in diameter towards the top, 11 to 12 towards the base, and 50 feet deep.

"When the roof of the quarry is exposed, along with its prismatic contraction, the workmen avail themselves of its fissures, by inserting into them levers and wedges of iron, and are thus enabled to separate considerable portions of the columns, for the purpose of constructing millstones from 4 to 5 feet in diameter.

"As soon as a first void has been thus obtained, the labourers manœuvre more at their ease, and, in detaching the stones, as well as in drawing them out of the quarry, by the aid of simple and ingenious machines moved by men or by oxen, there is in time established in these subterranean caverns spacious workhouses, the roofs of which are formed by prismatic blocks allowed to remain in their place, which in projecting, after the suspended manner of stalactites, are more or less irregularly supported by strong columnar prisms, likewise permitted to remain.

"Lastly, if any great natural fissure allow a tunnel to be pierced on one side, which ascends and rises to day, however rapid may be its course, it becomes of the greatest utility in the service of the quarry, because from that time the great opening is exclusively employed for the labour of extracting the millstones, which would otherwise be interrupted by the workmen, who are obliged, in entering into the quarry, or in going out of it, to make use of the rope by which the millstones are lifted up, from which there has resulted more than one accident. Thus, a quarry in which it has not been possible to obtain such an egress, is less advantageous than one which is provided with it."

These are all the extracts from M. Faujas St Fond's long memoir which it is necessary to give.

Of the number of quarries which were worked in the lava of Mennig when I visited them, I cannot speak with precision. In the year 1822 they amounted to ten, the largest of which was worked by eight men, and the smallest by four. In such request have the millstones of Mennig been long held, that they are exported to Holland, England, Russia, the Antilles, America, and even to the East Indies. The largest and best are said to fetch upon the spot eighty to ninety dollars.

Besides the quarries of Mennig, similar ones are worked in other places, particularly in the lava field of Kottenheim and Mayen. But the lava of Mayen is not reckoned so good for millstones as that of Mennig, for which reason it is more esteemed as a hard and firm stone proper for door and window lintels.

### (*e.*) *Quarries of Tufa.*

The quarrying of the tufa of the basin of Neuwied has in modern times much exceeded what was achieved by the Romans, by whom this substance, for architectural designs, was in greater demand than during the middle ages. At the present day, the chief quarries of tufa are at the Gansehals, Bell, the valley of the Bruhl, and at Kruft and Plaidt.

The tufa of the Gansehals is in great request. The little porosity which it displays, when compared with other tufas,—its more firm texture, and, as a consequence, its greater specific gravity and hardness, recommend it for architectural purposes; and, in conjunction with its power of resisting heat, as an *oven-stone*, whence has arisen the peculiar title which it bears. The mountain masses of this substance, which I have regarded in the light of moya that has overflowed from the valley of Rieden, are extensively quarried. Spacious caves are hollowed out in them, the roofs of which are supported by pillars eighteen to twenty-one feet high. (*See the Views given of the quarries of Gansehals in pages* 44 *and* 48.)

The tufa of Bruhl, or of Plaidt, is, when compared with that of the Gansehals and of Bell, very porous, yet it seems to have been most in demand by the Romans for architectural requisitions, although, in the present period, it is only used in the construction of cottages, or for the manufacture of sainted images. It is also softer than the Ovenstone, and more light.

But, while these qualities of the tufa of Bruhl, or of Plaidt, are at the present day considered unfavourable to the employment of it for architectural objects, except for the construction of light arches, it has been discovered, when ground down to a state of powder, to have the property of setting under water. This property first recommended it, about the beginning of the last century, to the notice of the Hollanders, for the purpose of constructing their dikes. One hundred parts of the Andernach tuffstein (whether that of Bruhl or of Kruft is not said) were found to contain 55 to 57 parts of silex, 6 to 6½ parts of calcareous matter, 27 to 28 parts of alumina, and 8 to 8½ of ferruginous matter.

The tuffstein, when intended to be applied to this purpose, is raised from the quarries in small blocks, not exceeding 5 or 6lbs. The hardest, roughest, and dryest, are said to be selected as the best for exportation. It is then reduced to powder by means of mills, (of which there are five or six in the Bruhlbach,) when it acquires the name of *Trass*. When this substance is mixed with an equal part of strong lime, and well ground, it is said to form a perfect cement, which not only resists the effects of common water, but also of the sea, beneath which it soon hardens.

In the valley of Bruhl, as I have stated, (page 139,) two va-

rieties of tuffstein are quarried. A lower bed, of a bluish-grey colour, is said, when pulverized, to harden the quickest under water, but, above water, to be too friable for use; its place, under these last-mentioned circumstances, being better supplied by an upper bed, or yellowish-grey variety, which, if less applicable to hydraulic purposes, does not above water dry so quickly.

As the article of tuffstein, which is sometimes exported in an unground, and, at other times, in a ground, or *trassy* state, forms a considerable object of commerce, being even exported by the Dutch to the East Indies, numerous quarries are opened in the valley of the Bruhl, as well as at Kruft and Plaidt, where a busy scene is presented. The tuffstein quarries of Bruhl alone are said to employ from eighty to one hundred persons.

### (*f.*) *The quarrying of Conglomerate beds of Pumice.*

The conglomerate beds of pumice-stone of Engers and other places are extensively quarried. Being of a loose texture, this substance is easily cut with hatchets, and separated from the quarry in the form of bricks. It is in requisition on account of its remarkable lightness, which renders it particularly adapted for the interior walls or divisions of houses, for chimney flues, or for roofs. As it is unable to resist the atmosphere or weather, it is never used for exposed buildings or walls.

M. De Wyck, however, remarks, that a heavier conglomerate rock, consisting of volcanic sand, rapilli, and pumice-stone gerolle, is quarried at St Thomas's Mills, the Weissenthurm, Saftig, &c. which is useful for the filling in of outer walls. It is also used to form the small square stones with which the walls of the peasants' houses and garden enclosures are built. These building-stones stand the weather.

### (*g.*) *The use to which the Loess is applied.*

In the next place,—the loess or diluvial deposit of the basin of Neuwied is in some little request. It is in demand for the culture of vines, being considered, when mixed with a proportional quantity of animal manure, as affording to them a generous soil.

### (*h.*) *The changes effected upon the soil.*

With regard to the influence of man upon the vegetable soil of the basin of Neuwied, this inquiry is the exclusive province of the agriculturist. The greatest diversity of soils, as might be expected, here subsists, owing to the corresponding varieties of rocks which characterize this district. Vines chiefly flourish on the right bank of the Rhine, near the village of Leudesdorf. "At eight hundred feet above the level of the sea," according to Pro-

fessor Steininger, "vines are everywhere planted, along with apricot, peach, and plum-trees. In several places are cultivated chesnuts, almonds, millet, maize, and tobacco. The corn land is highly productive. Clover culture is rare. Cows and oxen meet with scanty supplies of food. The horses are small, but strong. The sheep are numerous, and furnish good wool and savoury food. The beech in mountain regions is of importance for the feeding of swine. In the high lands corn is seldom brought into the barn before September; and in those which approach the Eifel, where are numerous turf swamps, the greater part of the less fruitful lands lies idle."

The influence of man upon the forests, which in some places thickly conceal the soil of the basin of Neuwied, continues to be felt. Much timber is annually felled, which is transported down the Rhine in rafts from Namedy.

Lastly, the influence of man upon the native animals of the district is still experienced, though proportionally less than in the time of the Romans, who first began to thin the forests of Germany of their original wild inhabitants, for the purpose of supplying the demand for exhibitions in the arenas of Rome. At the present day, the wild boar and the wolf subsist in numbers.

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But I must now conclude.—We have at length seen, that when subsequently to the diluvial catastrophe man appeared upon the surface of the basin of Neuwied, it had undergone a drainage, and volcanic convulsions had ceased. The vegetable soil became adapted for his sustenance, and, when the Roman Eagle frowned amidst the subjugation of Teutonic tribes, the volcanos which, at the time they burst forth, would, to the limited foresight of man, if he had then existed, have appeared to bode no other result than awful desolation, began to administer to the conveniences, and even to the luxuries, of the human race. Torrents of lava, congealed into a porous basalt resembling products of Vesuvius or Etna, which the Romans had been accustomed to form into millstones, were, upon the banks of the Rhine, quarried for the self-same purpose, while the continuance of the labour, during a period of nearly two thousand years, has given employment to numerous individuals, who frame them for the use of the inhabitants of the north-west of Europe, and even of distant colonies.

Eruptions of moya or mud have been destined to no less im-

portant uses. We have seen that the coarser kinds, such as occur near Rieden or Bell, from their quality of resisting heat, are in demand as oven-stones, and, from the facility with which they are wrought, are subjected to other economical purposes. We have also noticed, that, in Bruhl, the tuffstein, once used by the Romans for the requisitions of architecture, became in a later period extensively quarried for the demand of the industrious Hollanders, who have been enabled by it to more effectually protect their dikes against the formidable inroads of the ocean. The diluvial loess, and the submerged pumice of Engers, have likewise their subordinate uses.

Lastly, even the gases which continue to escape from the volcanic focus, indicative of an energy that is rather quiescent than extinct, have been rendered subservient to the luxuries of the human race. The carbonated waters of Tonistein are collected and dispersed over many parts of Germany to administer to the luxuries of the table, being esteemed, during the hot months of summer, as a gratifying addition to the product of the Rhenish vines.

If such are among the results of volcanoes, these visitations of Providence become disarmed of many of their terrors, and, independently of more weighty reasons of a physical nature, we must admire them, even in their most appalling paroxysms, as the apparent harbingers of new enjoyment to successive inhabitants of the human race.

## CHAPTER XXXIII.

### THE NATURAL PROCESSES OR OCCURRENCES WHICH ARE RECORDED TO HAVE TAKEN PLACE DURING THE HISTORIC TIMES OF THE BASIN OF NEUWIED.

THE natural processes or occurrences which are confined to the historic times of the basin of Neuwied, must be regarded as inconsiderable. The investigations which they suggest distribute themselves under the following heads:

1*st*, The meteorological changes which might have taken place; 2*dly*, the shocks of earthquakes which have been recorded; 3*dly*, the continued activity of gaseous exhalations or mineral springs; 4*thly*, the changes to which the channels of the Rhine and its subsidiary streams might have been subject; 5*thly*, the process of disintegration which might have been going on among the firmer and harder materials of rocks, such, for instance,

as strata of clay-slate, or trachytes and basalts; *6thly*, the process of disintegration which tufaceous deposits, or the newer and softer strata of a tertiary date might have experienced; and, *7thly*, the removal and transportation of loose materials either deposited by streams and rivers, or which had been ejected from volcanos then become extinct.

*1st, The Meteorological changes which might have taken place.*

Under this head a mere blank is presented. Among the records of the basin of Neuwied, I can find no meteorological occurrences recorded which have contributed to effect any particular change on its surface.

It is, in fact, a digression, under this head, to mention the popular notion which prevails in the vicinity of Mennig, that the basaltic lava of this district influences the temperature of the air, as well as its electric states. M. De Wyck states that in the mill-stone quarries of Niedermennig, which are scarcely 100 feet deep, ice is found nearly the whole summer, while the temperature, even in August, approximates to the freezing point. And, with regard to the influence which basalt is supposed to have upon the electric states of the air, it is the prevailing opinion, that on account of the village of Obermennig having been built upon basaltic lava, it has never been struck with lightning. It is even supposed by the philosophers of the village, that, owing to the tower of the church having been constructed of basaltic materials, this building, but more particularly its cross, which, by means of iron bars, is connected with the basaltic stones of the steeple, is thereby preserved from the effects of lightning. The less inquiring multitude, however, have a more ready hypothesis for the immunity of their cross from electrical fire, which preservative effect is attributed to the miraculous interference of Saint Genevieve. "Often," adds M. De Wyck, "when a tempest broods over the village, there appears a flame upon the cross, when the villagers immediately exclaim, 'The cross of our beloved Lady Genevieve is lighted up.'"

*2dly, The Shocks of Earthquakes which have been recorded.*

Under this head there is nearly as great a blank as under the last. It has been remarked by Dr Daubeny, (p. 368 of his work on volcanos,) that shocks of volcanos are common along the line of German rivers. But, with regard to any remarkable ones, which, since historic times, might have affected the basin of Neuwied, I can find no very striking record.

In the years 1755 and 1756, when the shocks of Lisbon took place, the Lower Rheinland did not partake much more than many

other distant parts of Europe in the commotion. The earthquake is said at Coblentz to have been violent, as well as at Dusseldorf and Duren.

Four years ago, A. D. 1828, when an earthquake prevailed in the Netherlands, the shock was felt along much of the course of the Lower Rhine, namely, from Nimuegen to Coblentz.

*3dly, The continued activity of Gaseous Exhalations, and Mineral Springs.*

In a former chapter (page 233,) I remarked, that although eruptions of pumice had wholly ceased, gaseous exhalations, or *mofettas*, and mineral wells, most of which, in their earliest developement, must be considered as having had a date of origin fully as remote as that of the volcanic explosions or convulsions with which they were first coincident, have continued to survive, and to form the only indications at present subsisting, with perhaps the exception of a few occasional earthquakes, that the volcanic energy is not wholly inactive.

These mofettas and mineral wells, most of them of great antiquity, certainly prove that since the cessation of eruptions of pumice, chemical actions have been going on in the volcanic focus, by which various gases have been evolved, some of which, in the course of their elaboration, have been condensed so as to form different saline compounds, and have long found a ready escape to the surface of the earth through the various fissures which have been induced during a prolonged series of volcanic convulsions. Such as are still going on I shall describe under the title of *Mofettas*, and mineral wells.

The great fissure through which gaseous fluids have most readily found an escape is the crater of Laach. Accordingly, aeriform substances, apparently condensed during their escape, have long ascended in such immense volumes through this aperture, as to have been enabled to impart decided chemical properties to its waters. The carbonate of soda has in particular been detected as an ingredient. Mofettas, giving vent to the extrication of carbonic acid gas, are affirmed to be so strong as to prove fatal to the birds which cross the lake ;—a legend resembling that of the lake Avernus in Italy. No less exaggerated is the popular report, that the crater gives rise to three thousand springs. *

Another Mofetta arises from the deep marsh which forms the extinct crater of Wehr. The carbonic acid given out from it is said to be in such a quantity, that, owing to this exhalation, as

* The principal Mofetta of the Laacher-See is said to be some few paces south of a well known bed of potter's clay, where a deep hole has been dug for the still greater facilitation of its escape.

well as to the softness which it causes in the moss, it is affirmed that it cannot be approached with impunity, and that cattle sink in it, and even disappear.

Other Mofettas occur near Gleis and near Bell.

To the gaseous exhalations of the valley of the Bruhl, whence have probably been derived the saline efflorescences which appear to exude from the tuffstein, I have before alluded. One hundred parts of the saline matter were found to yield about 8$\frac{3}{4}$ parts of sulphuric acid, 6$\frac{3}{4}$ of muriatic acid, 20$\frac{3}{4}$ of carbonic acid, and 63$\frac{3}{4}$ of potash and soda. (*See* p. 141.)

It is not improbable also, from certain historical records, that, at intervals, inflammable exhalations of gas might have arisen, of which two instances are cited.

The first of these has been inferred from rather an obscure passage of Tacitus, who states, that during the reign of Tiberius Cesar, in the country of the Juhones, a fire issued from the earth, which, after destroying several towns and villages, extended even to the walls of Cologne: " Sed civitas Juhonum, socia nobis, malo improviso afflicta est. Nam ignes terrâ editi, villas, arva, vicos passim corripiebant. Ferebanturque in ipsa conditæ nuper coloniæ mœnia, neque extingui poterant; non si imbres caderent, non si fluvialibus aquis, aut quo alio humore niterentur: donec inopiâ remedii, et ira cladis, agrestes quidam eminus saxa jacere, dein residentibus flammis proprius suggressi, ictu fustium, aliisque verberibus, ut feras absterrebant. Postrema tegmina corpori direpta injiciunt, quanto magis profana, et usu polluta, tanto magis oppressura ignes."—Tac. Ann. Lib. xiii.

Regarding this passage it has been very properly observed by Dr Daubeny, that the fire rather seems to have arisen from a disengagement of inflammable gas, than, as some geologists have supposed, from the usual concomitants of a volcanic eruption of the Eifel. With respect to the exact locality whence the inflammable gas may be supposed to have emanated, there is the greatest obscurity, as antiquaries are not decided what was the proper country of the Juhones. The spreading of the flames to the walls of Cologne seems to have been induced by the fire having kindled such inflammable materials as brushwood or heather;—an inference which is readily made from the circumstance of its having been checked by vollies of stones, or stifled by throwing upon it foul clothes. Under these circumstances, the fire which spread to the walls of Cologne must have resembled the phenomenon, which, during a remarkable dry season, lately took place in England, when various moor-lands, owing either to spontaneous or accidental combustion, exhibited spreading flames to a most remarkable extent.

I can find little difference in the phenomenon which is thus re-

corded by Tacitus, and a much later one which is referred to the year 1780. It is described by Steininger, who no doubt derives his account from some authentic historical document. The locality where a supposed disengagement of inflammable gas took place, is ascribed either to the lake of Laach, or, with more plausibility, to a round marshy valley, situated between Bell, Obermennig, and the Forst. From this last-mentioned site, very like that of an ancient crater, (see page 109,) which opens towards Thur, it is said that the moory soil, in a burning state, flowed down towards the village, and threatened it with destruction.

But quitting the field of conjecture, into which I have been involved by these imperfect narratives, I shall next consider the mineral wells of the Basin of Neuwied.

The minerals wells in the basin of Neuwied are very numerous.

The famous well of Tonistein has been before described, (page 141;) but I must now remark, that the proportion of the chemical ingredients contained in it has not yet been examined with a correctness which claims an unreserved regard. From two analyses which have been made, severally very different in their results, the mean estimate of carbonic acid gas contained in one cubic inch of water has been variously guessed at one and at two cubic inches. The ingredients obtained by M. Funke from evaporation have been before stated; but their proportion has been so differently estimated by another chemist, M. Mohr of Coblentz, that other and more satisfactory experiments are demanded. In each result, the carbonate of lime has been yielded in considerable abundance; but, with regard to the proportion of the carbonate of soda, there is a great discrepancy, and not much less so respecting the carbonate of iron. Other ingredients obtained by evaporation are the muriate of soda, and the sulphate of soda.

The Heilbrunner well near Kehl was another spring to which I had occasion to allude. Less carbonic acid gas appears to have been given out from it than from the spring of Tonistein. It also appears to have afforded from evaporation larger proportions of other ingredients, as, for instance, of the carbonate, sulphate, and muriate of soda and of the carbonate of iron; as well as to have shewn a further difference by yielding the carbonate of magnesia. But a more accurate examination is, I suspect, even in this case demanded. (See page 142.) The water is said to have a temperature of 8½ to 9 degrees of Reaumur. It very soon after an exposure to the air becomes muddy, and leaves a deposit of a milky colour.—Another well also, the Broch, is said to break out from a rock with great force, about a league from the spring of Heilbrun-

ner.—A third saline spring connected with the trass valley of the Bruhl, is found near Wassenach, but its ingredients have not hitherto met with much examination.

Near the lava flow of Mennig is a mineral spring, named the Kesselborns of Mennig, which has been examined by M. Funke. From twenty pounds of water he obtained, by evaporation, the following solid matters:—of the carbonate of soda 4 grains; of the muriate of soda $3\frac{1}{2}$ grains; of the sulphate of soda 4 grains; of the carbonate of lime 10 grains; and of the carbonate of iron 4 grains; total $25\frac{1}{2}$ grains. This spring, which occurs near Obermennig, is celebrated as an useful chalybeate. It is said to contain four times as much of the carbonate of iron as that of the Heilbrunner well, and eight times as much as that of Tonistein. At Niedermennig is a similar spring, but much weaker.

At Ober and Nieder Zissen are wells of partly a similar character to the others described, except that they are said to yield less of the sulphate of soda.

Another powerful well is at Frauenkirch, which, from the nature of its deposit, appeared to me to yield more iron than the other springs which I have cited.

But I am wearied with attempting a recapitulation of the qualities of waters which have been hitherto examined with such little care. It is sufficient to enumerate the localities of other springs, which are as follows:—at Burg Bruhl, on the left bank of the Brohlbach, where a very clear and cold spring bears the name of the Kesselbrunner, at Leyen, in the valley of Bell, at Bassenheim, at the Schmalberg, near Thur, at Plaidt, near Burresheim, where the spring is named the Solsborn, at Volkesfield, Rieden, and Gleis. But, no doubt, there are many others.

A very clear and copious spring, which issues from volcanic rocks not far from Andernach, is not possessed of any particular mineral qualities. It appears to have been early availed of by the inhabitants, to supply the city with water, to which it is conducted by very ancient conduits. Other fresh water wells are said to issue from beds of pumice near Kruft and Miesenheim, as well as from a similar deposit in the Wiedbach.

[For various notices respecting the mofettas and mineral wells of the basin of Neuwied, the volume of M. Harless of Bonn may be consulted, entitled "Die Gesundbrunnen an Niederhein," &c. &c.]

*4thly, The changes to which the Channels of the Rhine and its subsidiary streams might have been subject.*

That the channel of the Rhine, which flows through the basin of Neuwied, has since historic times experienced some alteration or deepening, must be admitted. But, owing to the very gradual descent of the river from Coblentz to Andernach, it is so small as

to be scarcely perceptible. Indeed, it is difficult to detect any alteration in the channel of the river since the tertiary epoch, as the lava which flowed from the hill of Fornich into the bed of the Rhine still appears near the ancient level of the river.

The alteration of the channel of the Rhine is inferred from a tradition that the ancient kings of Austrasia could from their castle or palace at Andernach fish from their windows into the Rhine. But, from an examination of the site, I am convinced that this is a mistake. They could only have fished from a small stream, the Andert, which, in the earliest state of Andernach, did nothing more than communicate with the Rhine.

The deepening, or other alterations in the channels of such streams as flowed down considerable declivities before joining the Rhine, is an effect much more to be expected, which may be traced in various parts of the course of the Nette. At the Rauschen Mill, near Saftig, the Nette has been noticed by writers as forcing its way through basaltic lava, and as forming in its course picturesque falls. But in this instance the commencement of the deepening is referable to a far more ancient date than historic times.

*5thly, The process of disintegration going on among the firmer and harder materials of rocks, such, for instance, as strata of clay-slate, or formations of trachyte and basalt.*

Although a newer gravel, formed by the wearing down and transportation of schistose strata, or of trachytic and basaltic rocks, is often observable, yet it is still trifling; and how much of it is due to the short period which is comprehended in the history of the human race, can in few instances be determined.

*6thly, The process of disintegration which tufaceous deposits, or the newer and softer strata of a tertiary date, might have undergone.*

The disintegration of the plastic clay and sand deposit observable in the basin of Neuwied, is more appreciable, and, in a few localities, as near Altwied and Mayen, may I think, be detected. This remark applies particularly to those localities where the deposit is little protected by a covering of turf or verdure. Owing to this cause, the loess in the vicinity of Andernach, which has been exposed to the weather by the intersections it has undergone during the levelling of roads, may be considered as particularly liable to a process of waste from rains and floods.

Owing also to rains and floods acting upon the softer strata of plastic clay, sand and tufa, which occur around the margin of the Laacher-see, particularly to the south of it, the depth as well as diameter of this crater has been much reduced. Its greatest diameter is said to be 8422 Rhenish feet; its lesser one 7643 feet; and its greatest depth, according to one author, 214 feet, but, according to another, $28\frac{1}{2}$ toises.

*7thly, The removal and transportation of such loose materials as had either been deposited by streams and rivers, or had been ejected from volcanos then beome extinct.*

Under this head much more may be remarked. The older gravel which had been deposited at the close of the teriary epoch, or after the diluvial catastrophe, as well as the loose ejections of black sand or pumice which had been strewed over the surface of the basin of Neuwied, have certainly undergone, by rains or mountain torrents, such a removal and transportation, as to have eventually concealed under a deep covering many ancient works of art, commencing with those of the Romans. This is particularly observable upon the flat grounds on the right bank of the Rhine, which boasted of the cities of Victoria and Rigodulum.

In many places the action of rains or torrents upon fragments of pumice has occasionally caused among them a partial conglomeration, and near Bendorf, in a partly consolidated bed of this kind, it is presumable that a coin of Vespasian, which has given rise to a needless argument upon the period when the volcanos of the basin of Neuwied were in activity, has been found.*

Near Neuwied, a Roman road is said to have been discovered at a depth of nine or ten feet below the present surface of the ground. This discovery, which I quote from Schreiber's Guide to the Rhine, I cannot confirm from my own observation, although I am disposed to credit it, from the great removal and transportation which I observed to have taken place of the pumice which had been drifted from the slope of the hills at the foot of the Westerwald to the whole of the low grounds bordering upon the river.

To a similar cause is to be attributed the deep covering of pumice and alluvial soil, by which the foundations of the Roman city of Victoria, which had been destroyed and burnt to the ground by barbarians, remained for many centuries concealed. The good taste of Prince Maximilian of Neuwied has lately directed these foundations to be explored, and seldom, except in the excavations of Pompeii or Herculaneum, have the zealous toils of the antiquary been more richly rewarded. The clearing away of the pumice and soil, which, in its removal and transportation by rains had covered the whole of this Roman city, elucidate various historical incidents connected with its destruction, upon which history had thrown a veil. Recent excavations have proved, 1*st*, that the city ceased to exist from about the time of Gallienus; 2*d*, that the contest between the Barbarians and the Romans, when the

* It has been imagined, however, that the coin was found in a deeper and older bed of conglomerate pumice. But this assertion rests upon no better authority than the very fallible one of workmen. (For the contention which this coin has occasioned, reference may be made to the incidental remarks of M. Steininger, given in his memoirs, and the answers to them in the "Rheinland Westphalen," edited by M. Noeggerath.)

former had surprised the city of Victoria, was waged in the very houses; *3d*, that all the furniture, valuables, and household gods, were destroyed along with the Roman habitations; *4th*, that the city was afterwards devoted to the flames; and *5th*, that after a great part of the city had been burnt, what remained was levelled to the ground.

(1.) The evidence of the complete destruction of Victoria is, that no coins were found in the ruins of this city later than the time of Gallienus.

(2.) The evidence that the city was surprised, and that the battle was carried on within the very houses, was inferred from a multitude of exposures, caused by the removal of accumulated beds of pumice and soil. Within the foundations of the buildings bones of men, as well as of various domestic animals, consisting of oxen, swine, dogs, &c. were strewed everywhere, either singly or promiscuously. Among the skeletons found, to one of them belonged a shield which had been pierced by a weapon of Teutonic workmanship.

(3.) The evidence that all or most of the furniture, valuables, and household gods found within the Roman houses were destroyed, has been amply confirmed by the very few articles which were discovered entire. Myriads of fragments were to be seen consisting of various kinds of earthen-ware, plates, crocks, cups, and culinary utensils, and vessels of various kinds; of glass bottoms, necks of flasks, and pieces of glass plate; of hand-mills; of pillars composed of the hardest stones of the district; of altars wrought from marble, or from red and white sandstone, quarried near Mayence and Treves; of the hardest metallic utensils, particularly of iron, which some extraordinary force must have shivered; or of ranges of altars, statues and images of the gods which had been destroyed during the demolition of the prætorium,—the pieces having been so shattered and dispersed as to defy all attempts towards their re-union. *

(4.) The evidence, that, subsequently to the slaughter of the inhabitants of Victoria within their houses, where they had been surprised, and to the destruction of the furniture, a burning of the town had ensued, was afforded by the charcoal and branded beams which were observed deep in the floors of the chambers. The heat in many edifices appears to have been so great, that not only was the thickest glass melted, but likewise pieces of ore.

(5.) The last evidence, that after a great part of the town had been destroyed by fire, what remained was levelled to the ground, was proved by the immense remains of columns of various marbles, or

* It is rather curious that immense heaps of oyster-shells were found among the ruins of this city, giving proofs of the predilection of the Romans to this particular shell-fish, in addition to the similar evidence which is afforded from the written records of this people.

of tuffstein, which were generally strewed over the site.—In an early period of the middle ages, many of these fragments were removed to decorate the ecclesiastical structures of the Christian period.

These were the remarkable historical facts developed by the removal of the pumice, gravel, or soil which had long concealed the foundations of the ancient city of Victoria. The choicest or most entire relics obtained from this interesting site now adorn the museum of Prince Maximilian of Neuwied.

In many other places, also, besides the neighbourhood of Niederbeiber, Roman remains have been found; but they give no particular information of the changes which might have occurred in the alluvial or pumiceous covering of the basin of Neuwied. The Roman sarcophagi, or burial-places, discovered in various sites, as at Weissenthurm, the Nette Muhle Villa, Bassenheim, Saftig, Rubenach, and other places, afford no evidence whatever of recent alterations of the soil, as they must have been originally inhumed to a greater or less depth.

## CHAPTER XXXIV.

### CONCLUSION.

My labours are at length completed. I have sought to connect, in a species of history, all the varied volcanic phenomena which the basin of Neuwied presents, in which an attempt has been made to exhibit in succession each physical change which has been going on during the contemporaneous or successive activity of a series of volcanos, remarkable for their number, as well as for their being crowded together in a very limited space.

The summary of this history I cannot better exhibit than in a tabular view of the superposition of rocks and strata in the basin of Neuwied, in which I have endeavoured to include the various volcanic eruptions which were contemporaneous with successive deposits.

With this result of my researches I must now bid my Reader FAREWELL.

Should HE be yet an aspirant in geology,—earnest to prosecute the volcanic department of it,—I would accompany my valediction with the TRIADIC wish, expressed in the peculiar, yet nervous, language of the ancient British Bard:—That HE may possess AN EYE THAT CAN SEE NATURE;—A HEART THAT CAN FEEL NATURE;—AND A RESOLUTION THAT DARES FOLLOW NATURE.

**Table of the Superposition of Rocks and Strata in the Basin of Neuwied, comprehending the volcanic eruptions which were contemporaneous with successive deposits.**

| | | | |
|---|---|---|---|
| Historic times. | Artificial changes on the rocks and soil effected by the human race, and the natural changes recorded by history. | Cessation of eruptions of pumice, and the continued subsistence of gaseous exhalations and mineral wells. | |
| Commencement of the present epoch. | Completion of the drainage of the basin; newer gravel, &c. deposited. | Continuation of showers of pumice from the Humrichs. | |
| | | The mud eruption, accompanied by showers of pumice from the Humrichs; the convulsions in the vicinity of Niedermennig; and the eruption of pumice near Thur. | Latest and prolonged eruptions from the crater of Laach. |
| Elevation of the Alps. | The diluvial deposit of Loess, and renewed elevation of the waters. | Commencement of the eruptions of pumice yielded by the Humrichs. | Latest and prolonged eruptions from the crater of Laach. |
| Newer tertiary beds. | The gradual drainage of the basin of Neuwied, and the beds of gravel, black volcanic sand, &c. by which its removed beds of sand, plastic clay, and brown coal were replaced;—along with a deposit of travertine in the valley of Bruhl and other places. | Basaltic eruptions of the Carmelenberg, &c. the Humrichs of Saftig, the lava flow of Werner's Ech, Humrichs of Plaidt, Kretz, and Kruft, the small crater between Nickenich and Kretz. | Latest and prolonged eruptions from the crater of Laach. |
| | | Basaltic eruptions of the hill of Heidnerhof; the later ones of Fusel and Wehr; of Gleis, Weiber, Wabern, Volkesfeld, west of Laach, near Bell, the Hochstein, the Hoch Simmer, Ettringen, Kottenheim, Mennig, the Krufter-Ofen, the Rothenberg, &c. near Andernach, near Fornich, Lummerfeld, Kungskopfe, &c. and the basaltic eruptions around the crater of Laach. | |
| | | Quiescent interval. | |
| | | Eruptions of Boos, the Bausenberg, Herschenberg, Leileskopf, Steinberg, &c. | |
| Elevatn. of the Hundsruck, Taunus, &c. | Accumulation of quartz pebbles. | The early basalts of Rieden, of the Nurburg, and of the High Acht and its vicinity. | |
| Older tertiary beds. | Brown coal beds, &c. | Trachytic eruptions of Rieden, Fusel, Wehr, the vicinity of Hahnenbach, Olbruck, and the vicinity of the Nurburg. | |
| | Sand and plastic clay. | | |
| | Lower deposit of sand. | Interval free from eruptions. | |
| Elevation of secondary rocks. | Basin of Neuwied developed in its earliest tertiary form. | Crater of Laach broke out, accompanied (as it is presumed) with trachytic eruptions. | |
| Secondary epoch. | No secondary deposits extant. | | |
| Primary epoch. | Clay-slate and grauwacke-slate.<br>Mica-slate. } Concealed.<br>Gneiss.<br>Granite. | | |
| Volcanic focus. | Trachyte.<br>Basalt. | | |

THE END.

## DIRECTIONS TO THE BINDER.

### List of Maps and Views.

*1st*, Map of the Volcanic District bounded by the Rivers Nette and Bruhl on the Lower Rhine.—Fronting the Title-page.
*2d*, Two Views of the Laacher-See, - Fronting page 23
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In sheet K, a cancelled leaf, page 149 and 150, is to be replaced.

EDINBURGH:
PRINTED BY JOHN STARK,
*Old Assembly Close.*